The Engineer

LONDON, FRIDAY, APRIL 25, 1941.

PUBLIC NOTICES

BOROUGH OF TORQUAY

PLANT FOR SALE

The Borough of Torquay have FOR DISPOSAL a LARGE QUANTITY of SURPLUS CONTRACTORS' PLANT, now available for inspection at the site of the Sea Front Improvement Works, Torquay, for which TENDERS are INVITED.

The principal items include :—

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1 No. C.P.T. Diesel Air Compressor (2 tools) ;
15 cwt. Wickham Diesel Hoist ;
2 No. 10/7 High Delivery Millar's Concrete Mixers ;
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12 H.P. 1938 Standard Saloon Car ;
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Also Grabs, Bale Skips, Jubilee Wagons, Water Tanks, Air Tools, Surveying Instruments, &c.

Forms of Tender, together with Schedule of Plant, may be obtained on application to the Borough Engineer, Town Hall, Torquay, and must be delivered in a plain sealed envelope, endorsed "Tender for Plant," not later than Noon on Wednesday, 7th May, 1941, to the Town Clerk, Town Hall, Torquay.

HERBERT A. HIELD,
Town Clerk.

Town Hall, Torquay,
18th April, 1941. 7365

PATENTS AND DESIGNS ACTS, 1907 TO 1939.

Notice is Hereby Given that RAOUL ROLAND RAYMOND SARAZIN, of Villa "Les Surprises," rue du Chateau de la Chasse, Saint-Prix (Seine et Oise), France, SEEKS LEAVE to AMEND the SPECIFICATION of the application for Letters Patent No. 521,503 in respect of an invention entitled "Improvements in or relating to the Generation of Impulses."

Particulars of the proposed Amendment were set forth in No. 2725 of the Official Journal (Patents), published on April 17th, 1941.

Any person, or persons, may give Notice of Opposition to the Amendment by leaving Patents Form No. 19 at the Patent Office, 25, Southampton Buildings, London, W.C.2, within one calendar month from the date of publication of the said Journal.

M. F. LINDLEY,
7363 Comptroller-General.

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STANLEY DUMBELL,
7348 Registrar.

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The Engineer

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All correspondence dealing with Editorial, Advertising and Subscription Matters should be addressed to: 28, ESSEX STREET, STRAND, LONDON, W.C. 2

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Letters relating to the Advertisement and the Publishing Department of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

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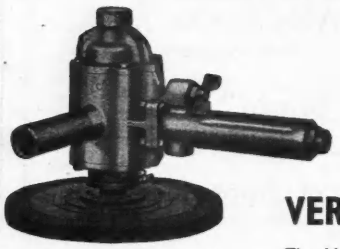

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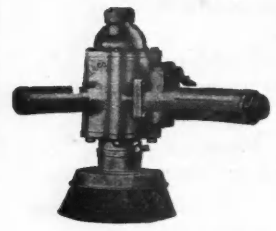

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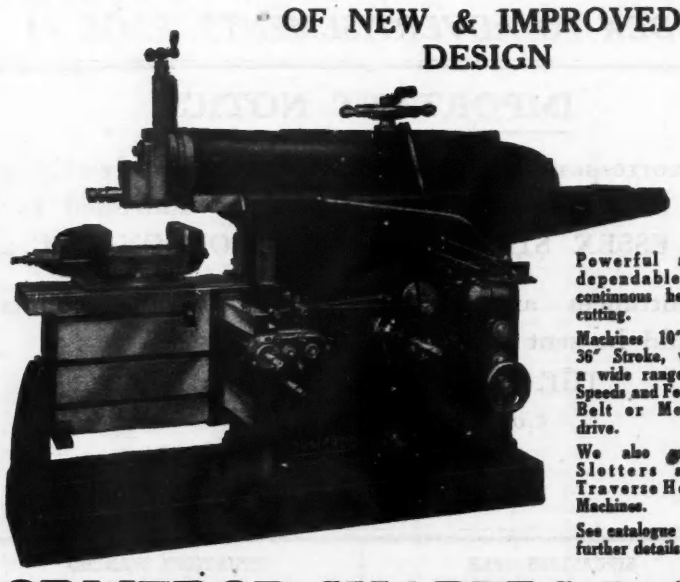

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American Tanks and Aeroplanes

ACCORDING to *The Times'* own correspondent in New York, the first medium-sized tank to be built by American private industry rolled out from the works of the American Locomotive Works, Schenectady, on Saturday last, eight months ahead of schedule. Three more should have left the works by now and once the run has fairly started the present order for 685 will be completed at the rate of three a day. The Baldwin Locomotive Works and the Chrysler (Motor) Corporation have also contracts for similar tanks and their output also is well in advance of programme dates. This medium tank is of American and British design. It weighs some 28 tons and is driven by a 400 H.P. Wright aeroplane engine, which, it is said, can give it a speed up to 50 m.p.h. on a good surface. It carries one 75 mm. gun and a 37 mm. A.A. gun, besides four heavy machine guns and a number of sub-machine guns. It is 18ft. long and 8ft. high and is provided with a revolving turret. . . . In the output of aircraft it is also reported that America is well ahead of schedule. A few days ago Mr. Robert A. Lovett, Assistant Secretary of War for Aviation, stated publicly that "Within three months American aeronautical equipment with military loads will have no equal at high altitudes anywhere in the world." He referred also to a new fighter, the "P 47," which has not yet been accepted officially, but had shown up exceedingly well in private trials.

Salvage Returns

THE total sales in February of salvage collected by local Councils showed an increase over January, the figures being £198,992, as against £187,720. Metal salvaged increased from 16,808 tons, valued at £44,988, to 19,307 tons, valued at £56,754. The tonnage of paper showed a slight decrease, amounting to 21,441 tons, as against 22,123 tons, and bones totalled 834 tons, a decrease of 74 tons. In comparing these figures with previous months it must be borne in mind that February was a short month and that the severe snowstorm in the third week caused much interruption of collection services. These figures of sales cover only collections by local authorities. They do not include material collected direct by merchants, nor do the metal returns include the village dump or railings schemes. Preliminary returns for March indicate a further all-round improvement in salvage collection. Meanwhile the Salvage Department of the Ministry of Supply is planning, with the collaboration of various municipal authorities, a series of local drives to stimulate the collection of paper, metal and bones. Lord Portal, Joint Parliamentary Secretary to the Ministry of Supply, has explained that in this way it is hoped to adapt salvage campaigns to widely differing local conditions. Already household salvage has, he says, saved Britain sixty shiploads of paper and enough metal to build 20,000 tanks. This year we must do better still.

The Crystal Palace Towers

MOST of the Crystal Palace was destroyed by fire in November, 1936, and in the early part of last year the Trustees decided to dispose of the two towers, which did not form part of the original design. The Palace was built without provision for heating, and Brunel was asked to design chimneys to carry off the smoke from the furnaces needed to heat the structure. The suggestion was made that the chimneys might also be used to carry water tanks to feed the fountains in the grounds. The two towers designed by Brunel were about 280ft. high by 40ft. diameter and were constructed of cast iron sections, each floor consisting of twelve sections, braced together by wrought iron tie bars. There were ten floors to each tower and a cast iron spiral staircase attached to a brick flue running up the centre of the tower extended from ground level to the top, where there was a large wrought iron tank, which supplied water for the fountains. Each tower included about 840 tons of wrought and cast iron, 570 tons of brickwork, 74 tons of woodwork, and 5 tons of glass. In the case of the north tower the water tank showed signs of wear some years ago, and a reinforced concrete tank was constructed inside it, the extra weight amounting to some 500 tons. In June last year the contract for the removal of the towers was placed with the dismantling department of George Cohen, Sons and Co., Ltd. The south tower, adjacent to the main Anerley Road, was the first to be dismantled. Owing to its proximity to the main thoroughfare a special protective "fan" was erected to safeguard the road. After the removal of the wooden dome the wrought iron tank at the top was cut away in large pieces and lowered to the ground by electric winch. A specially designed jib was used for dealing with the cast iron sections, each weighing approximately 4¾ tons, and this jib was attached to the brick flue, which acted as a kingpost. The foot of the jib was equipped with special steel rollers, which fitted into a steel runner strapped round the flue. The jib was held back to the flue by a similar steel strap and could thus move round in a complete circle. As each floor was dealt with the steel straps were loosened and lowered down the brick shaft to the next floor, a distance of approximately 20ft., after which the brick flue was broken away to within 5ft. of the top of the straps. On Wednesday of last week, April 16th, Messrs. Cohen demolished the north tower by felling it with the aid of 220 lb. of dynamite. The felling of the tower required very careful consideration, particularly in view of the 500-ton concrete tank at the top. It was finally decided to remove the tank before dropping the tower. The removal was carried out with the aid of pneumatic hammers and represented nearly two months' work. The plan consisted of blasting away six of the cast iron columns forming the bottom floor, together with the front portion of the brick flue and four of the small cast iron columns forming the support for the wooden floors, all the charges being fired simultaneously. The operation was carried through with complete success.

Dr. G. W. C. Kaye

THE National Physical Laboratory suffered a grave loss on April 16th, when Dr. Kaye, the familiar Superintendent of the Physics Department, died at his home. He was still a relatively young man, having been born in 1880. He was educated in science at the Royal College and at Trinity College, Cambridge, and was a D.Sc. of London University. Despite his exacting work at Teddington, he found or made time to fill many responsible offices and to deliver many important lectures and addresses. He was à Past-President of the Röntgen Society, Secretary, since 1928, of the International X-Ray and Radium Protection Committee, President, 1928–1929, of the British Institute of Radiology, and a member of the National Radium Commission, 1929–33, and of the Grand Council of the British Empire Cancer Campaign. At the Royal Society of Arts he delivered Cantor and Aldred lectures, and in 1926 was the Tyndall Lecturer at the Royal Institution. He was also Sylvanus Thompson Lecturer and medallist and last year was Stanley Melville Memorial Lecturer and Medallist. In 1937 he was President of Section A of the British Association, and two years later of the International Conference on Concert Pitch. He took a special interest in noise and related matters and was Chairman of the Noise Investigation Committee of the Ministry of Transport, of the Acoustics and Noise Committee of the B.S.I., and of the League of Nations International Commission on Noise and Housing. Besides being a lecturer he was the author of several well-known books on physics and kindred subjects.

Repair of H.M. Ships

IT was revealed publicly a few days ago by Colonel Knox, the Secretary of the U.S. Navy, that H.M.S. "Malaya" had recently arrived in New York for overhaul and repair. She is an old battleship (1915) of the "Queen Elizabeth" class, with eight 15in. guns in four twin turrets. All warships, whether they are damaged in action with the enemy or not, have to be maintained in first-class condition. In the present circumstances, the call upon their services is very exacting, and it was not surprising to hear from Colonel Knox that the "Malaya" was probably only the first of many that would be allocated to United States harbours for repairs. Unfortunately, some organs of the American Press have not always recognised the necessity of secrecy about the movements of ships, and Colonel Knox again impressed it on them, suggesting, moreover, that British ships would do well to arrive by night instead of by day. It was also stated by Colonel Knox that such ships brought in for repair would be given priority over everything else, but he hoped that, even so, the building programme of the American two-ocean navy would not be delayed.

All-Concrete Houses

THE restricted supplies of timber and the shortage of bricklayers, combined with the urgent need for more accommodation for war workers, have led the Scottish Special Housing Association, Ltd., to depart from the more usual methods of building and to adopt concrete for the walls, floors, roofs and stairs. The concrete for the walls is poured on the site into previously erected moulds of steel, the moulds being taken down and used again about twenty-four hours after the concrete is poured. In order to obtain the same insulating properties as those of cavity walls in brick, cellular concrete is used. The ground floors are normally of ordinary concrete poured on the site, pre-cast concrete beams being used for the upper floors and roofs. The concrete stairs are poured *in situ*, using the same steel shuttering as that used for the walls. The concrete roofs prevent entry into the houses of light incendiary bombs and, being flat, they are easy to patrol. The only timber used in the houses is for the door frames, door facings and skirtings, about one-quarter of a standard of timber per house being sufficient for these purposes. At Manchester a pair of experimental houses has been erected on the Wythenshawe Estate by the Corporation Housing Department Works Section. Here, too, the floors, roofs, and stairs are all composed of concrete. A notable difference, however, is to be found in the fact that the houses have pitched roofs of traditional appearance with pre-cast roof beams which in turn have been covered with a light-weight pre-cast slab from beam to beam and finally the slabs are covered with roof tiles. The stairs are composed of pre-cast units and are finished with a special granite aggregate. Other timber and metal saving units in the Manchester houses are pre-cast floor units and pre-cast ceiling joists to the bedrooms with fibrous plaster ceilings wired through to the concrete units. The concrete gutters are formed in concrete cast *in situ* and the rain water down spouts are in asbestos cement. A specially strengthened compartment adjacent to the kitchen has been provided, which could be used as an indoor air raid shelter.

Royalties on German Patents

WITH regard to the interest which has been aroused by recent reports in the Press that money is still being sent to Germany from this country as royalties for the privilege of making use of German inventions, the Chartered Institute of Patent Agents points out that under a general licence of the Board of Trade British subjects are permitted to send money to Germany as renewal fees in order to keep their British-owned German patents in force. Reciprocal privileges, the Institute adds, are allowed to enemy subjects. British subjects who are working under German-owned British patents, the Institute states, keep an account of royalties due, but these amounts are not sent to Germany, but have to be forwarded to the Department of the Custodian of Enemy Debts. It is therefore entirely wrong to suggest that this money is sent to Germany. It is further pointed out by the Institute that during the last war from 1914 to 1918 payments under licence from the Board of Trade, in order to maintain patents in force in enemy countries and to allow enemies to maintain British patents, were similarly permitted. Such a course, it is pointed out, had the advantage of avoiding the lapsing of valuable British rights which otherwise would have been lost.

Women in Industry

IN an address given at a "War Commentary" meeting arranged by the Ministry of Information at Caxton Hall on April 22nd, Miss Caroline Haslett, Adviser on Women's Training to the Ministry of Labour, said it seemed strange that in many cases we had to learn all over again that women were capable of skilled work, that they could take responsibility and show adaptability. That, however, had been so undeniably and universally demonstrated that there should never be a reversion to the old attitude of mind regarding women's ability. The establishment of the principle of "the rate for the job" indicates the attitude towards the worker in this war. It was the job that mattered and not the sex of the worker. Women who since the last war had become technicians—and there was quite a number of them—were able to render invaluable service. They were very largely instrumental in setting up early training for women. A special feature of the present war was the technical and scientific departments in which women were engaged. Specially selected women were given courses in range-finding and other scientific observations relating to predicted fire, and took their place in combatant units. Research work of many different kinds had engaged women whose special qualifications were of value. There had already been a great increase of women in normal industry since the last war, and they had naturally become absorbed in the war effort when firms changed over to armament production. There had, too, been a great influx of women into wartime industry, including our filling factories. New training schemes enabled women to undertake processes requiring some degree of skill. In nearly all of the forty Government Training Centres, in ninety-six Technical Colleges, and in forty-three employers' works women were training side by side with men. Women were now engaged in capstan lathe setting, oxy-acetylene welding, intricate wire rope splicing, and high-grade instrument work. They acted as charge hands, as forewomen, as supervisors, and they did inspection work. Some few women were works managers and deputy works managers. Work in an industrial establishment was not all the repetitive work that some people thought. For the intelligent and ambitious woman there was really skilled, fascinating work requiring the co-ordination of hand and eye and great concentration and accuracy.

Temperature and Latent Energy in Flame Gases

By Professor W. T. DAVID

FLAME gases are not just hot normal gases. It has been shown[1] that they contain a long-lived latent energy which probably resides as an excess of intra-molecular energy in a proportion of the tri-atomic molecules formed during combustion. The excess intra-molecular energy in these abnormal molecules appears to be of a type which cannot be handed over to the translational degrees of freedom during molecular collisions.

In virtue of the long-lived latent energy, the ideal flame gas temperature, calculated upon the basis of accurate specific heat and dissociation data, is not usually attained. It seems probable that when detonation is set up, the flame gases resulting very nearly attain the calculated temperature, but apart from this the temperature attained by the flame gases resulting from the combustion of any given homogeneous inflammable mixture depends greatly upon the manner in which combustion takes place. Under certain conditions it may be many hundreds of degrees Centigrade below the calculated temperature. Experiments are described in this article demonstrating this.

It is further shown that owing to latent energy the ideally calculated pressures are not fully attained in closed vessel explosions, even after allowing for the heat loss which takes place during explosion. For reasons which will appear, the approach of the measured explosion pressure

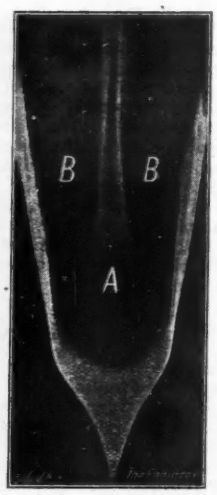


FIG. 1—FLAME FRONT AND AFTERGLOW

(corrected for heat loss) to the ideally calculated pressure becomes closer and closer as the size of the explosion vessel increases. Very little success in determining the specific heats of gases by the explosion method can therefore be expected unless very large vessels are used.

The latent energy seems to disappear and the abnormal molecules to become normalised when the flame gases come into contact with surface. An experiment which seems to prove this is described. It may be that the effectiveness of flame gases in many industrial processes results from the unloading of latent energy upon surface.

LUMINOSITY EXPERIMENTS

The following facts relating to the travel of flame, initiated by an electric spark, through a homogeneous inflammable gaseous mixture, are well established :—

(1) Flame photographs show that the flame front during the early stages of travel is of low luminosity. Later, however, it builds up a high luminosity indicating a high instantaneous pressure and temperature.

(2) Turbulent motion of the inflammable mixture before combustion has no influence upon the rate of travel of the flame front in the early stages, but has a marked influence upon it in the later stages.

It would seem therefore that in the early stages after ignition the flame propagation results from the diffusion of activated particles from the flame front (that is, by chain reaction mechanism), and that in the later stages it is propagated as a result of conduction and radiation of heat from the high temperature flame front into the adjacent unburnt gas—or perhaps it would be more correct to say that the propagation is thermally assisted in the later stages.[2]

The condition of the flame gases left behind the flame front would appear to depend very largely upon the method by which the flame is propagated. That this is so may be seen very clearly from flame photographs on which the luminosity (afterglow)

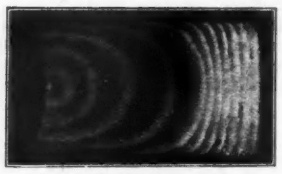


FIG. 2—FLAME FRONT IN SHORT TUBE

from the burnt gases is registered. In Fig. 1 is shown a photograph taken by Dr. O. C. de C. Ellis[3] on a revolving photographic film of the flame movement and the afterglow of the burnt gases as flame travels through a mixture of carbon monoxide and air contained in a glass tube closed at both ends. It will be seen that the afterglow from the gases which are first burnt (marked A) is considerable, but that from the gases burnt later (marked B) is very feeble. The sudden change in the intensity of the afterglow is remarkable, but it may be correlated with a sudden change in the intensity of the luminosity of the flame front, as shown in the series of instantaneous snapshot photographs reproduced in Figs. 2 and 3, the former relating to a short tube and the latter to a longer tube. An examination of the series of single snapshots, also taken by Ellis, reproduced in Fig. 4, lends further support to the view put forward; attention is specially directed to snapshot No. 7. Dr. A. S. Leah has made some preliminary measurements by means of a thin platinum-rhodium wire of the temperature of burnt gases and he finds that in the gases marked B in Fig. 1 the temperature is definitely higher than in those marked A in the same figure.

Similar experiments with thin platinum-rhodium wires were made some years ago in a very long (50ft. long) steel tube of 2in. diameter. The tube was filled with a thoroughly mixed inflammable gaseous mixture and ignited by an electric spark placed either at the centre of one of the end covers or at the centre of the tube. The temperature attained by the platinum wires after the flame had passed over them approached the ideally calculated temperature for the flame gases when the wires were placed some distance away

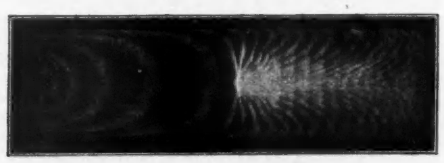


FIG. 3—FLAME FRONT IN LONG TUBE

from the spark, but over the first 9in. from the spark the wire temperatures measured were as shown in Table I :—

TABLE I

Distance from spark in inches	1½	...	8	...	9
Wire temperature, deg. Cent.	1570	...	1750	...	1810

It will be noticed that at 1½in. away from the spark, at which point the flame gases probably resulted from a combustion propagated purely by chain reaction mechanism, the temperature reached by the wire was only 1570 deg. Cent., whereas at 9in. away it was 1810 deg. Cent., that is, some 240 deg. Cent. higher. Previous experiments reported by the writer and his collaborators have led to the conclusion that the temperature rise resulting from the combustion of an inflammable gaseous mixture increases as the distance of flame travel from the igniting spark increases. The experiments now described give further support to this conclusion, and indicate that this is because in the early stages of combustion after spark ignition the mechanism of flame propagation differs from that in the later stages.

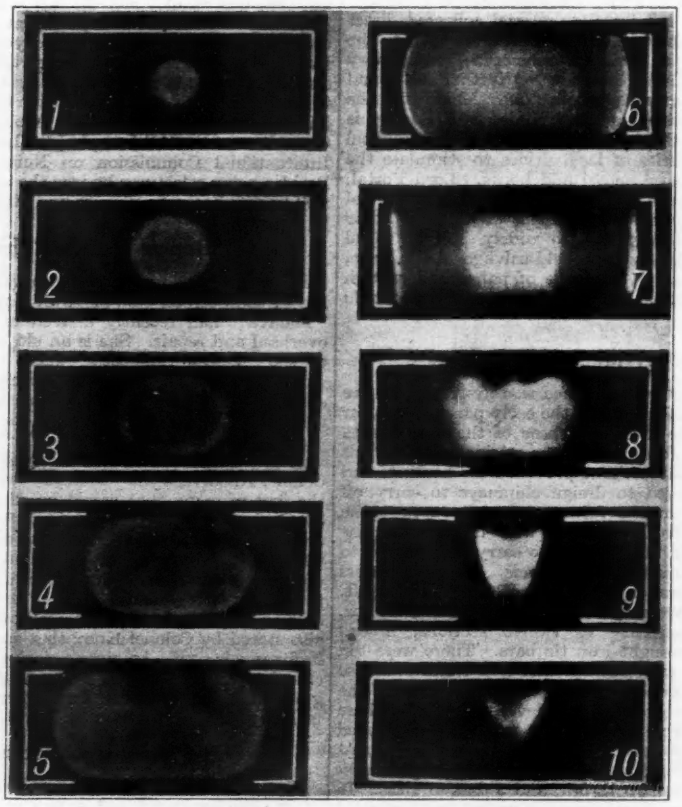


FIG. 4—SERIES OF PHOTOGRAPHS OF FLAME FRONT AND AFTERGLOW

TEMPERATURES MEASURED DURING THE PRE-PRESSURE PERIOD IN LARGE CLOSED VESSEL EXPLOSIONS

Large numbers of wire temperature experiments have been made during the early stages of com-

[1] "Temperature and Latent Energy in Flame Gases," THE ENGINEER, June 1st, 1934; *Phil. Mag.*, Vol. XXIII (1937), page 345; and other papers referred to therein.

[2] THE ENGINEER, June 7th, 1940, page 509.

[3] *The Photographic Journal*, September, 1935, page 494.

bustion after the central ignition of homogeneous inflammable mixtures contained in a spherical vessel of 18in. diameter.[4] The wires were placed about 1½in. from the spark and they measured the temperatures of the flame gases formed as a result of combustion propagated purely by chain reaction mechanism. Two types of wires were used. The one a plain platinum-rhodium wire, 0·0005in. diameter, and the other a quartz covered platinum-rhodium wire, of 0·0005in. overall diameter, which was manufactured by Messrs. Baker and Co., of Newark, U.S.A., by the Taylor process. The experimental arrangements are shown in Fig. 5.

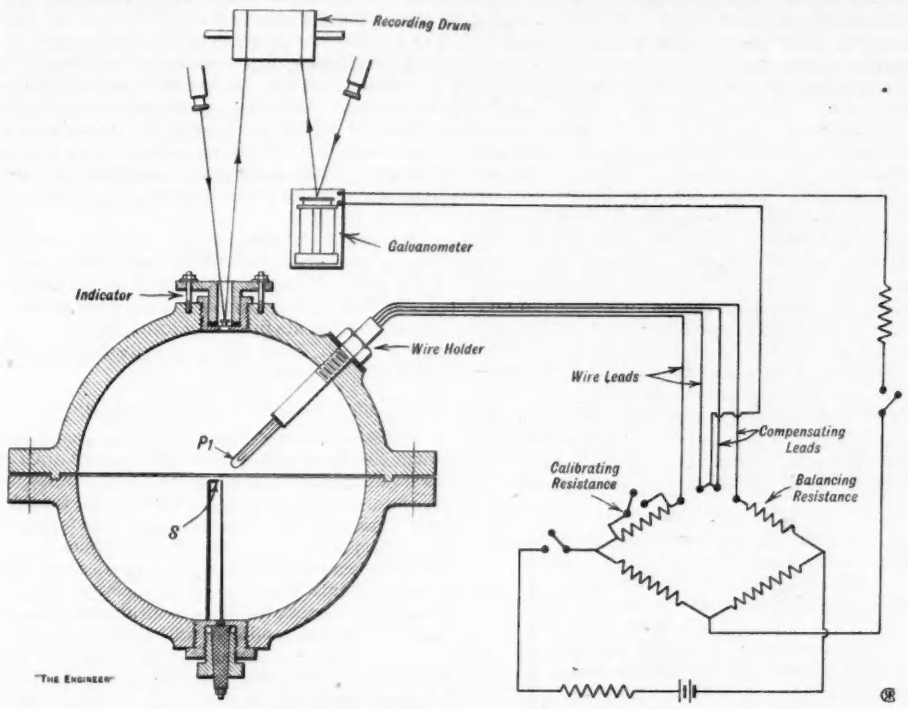


FIG. 5—ARRANGEMENT OF APPARATUS

It will be seen that a continuous record of the resistance of the wire (and therefore of its temperature), and of the pressure developed in the explosion vessel, was obtained upon a photographic film wrapped round the revolving drum. A typical record is shown in Fig. 6. The line P_oP_o represents the zero pressure, reckoned from the initial pressure in the vessel before ignition, and T_oT_o is the line of zero temperature corresponding to the resistance of the wire at the temperature of the gaseous mixture before inflammation takes place. At A the spark is passed. Shortly afterwards the flame reaches the platinum-rhodium wire, and as a result the wire temperature rises rapidly, as shown at B C. During the interval C D the temperature remains remarkably steady, but after D it begins to rise again. This rise is clearly due to the

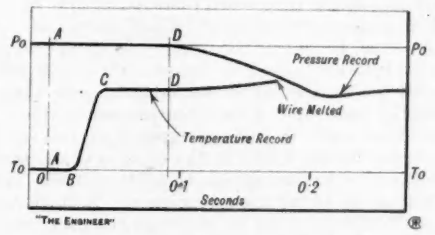


FIG. 6—TYPICAL EXPERIMENTAL RECORD

adiabatic compression of the inflamed gases surrounding the wire, for, as is shown by the indicator record, the pressure begins to rise at D. The interval A D is the " pre-pressure " interval, and during it there is no sensible rise of pressure. This is largely due to the fact that, although the flame has spread a considerable distance outward from the spark, the total volume inflamed is small in comparison with the total volume of the vessel.

As has been stated, the platinum-rhodium wire, after the initial rapid rise, is maintained at a steady temperature during the " pre-pressure " interval, and experiment has shown that the temperature may be maintained at its sensibly steady value for an even longer time[5] by prolonging the " pre-pressure " interval. This can easily be arranged by employing a larger explosion vessel. There is clear justification therefore for regarding the temperature C D as the final temperature reached by the flame gases, subject to corrections for losses of heat by radiation from the wire and from the inflamed gases.

The results of a series of experiments[6] with carbon monoxide-air mixtures of various strengths are shown in Fig. 7. The curve marked T_p shows the steadily maintained temperatures attained by the plain wire, and that marked T_q those attained by the quartz-covered wire. The curve marked T_i shows the calculated temperatures which would be ideally attained by the flame gases after combustion at constant pressure.

It will be seen that there are enormous differences between these curves. Both the plain and the covered wire temperatures are some hundreds of degrees Cent. below the calculated temperatures, and it might be thought at first sight that this is due to large radiation losses from the burnt gases and also from the wires. Measurement, however, has shown that the radiation loss by the hot gases is small, amounting only to 1 per cent., or

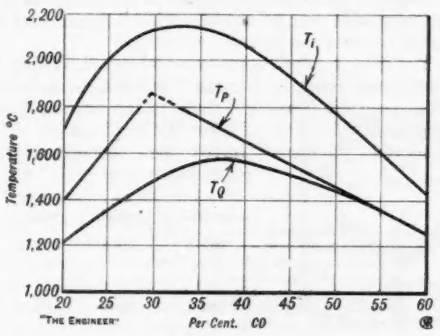


FIG. 7

at most 2 per cent., of the heat of combustion. The radiation loss from the wires is more difficult to measure, but it is clear from wire temperature measurements which have been made with inflammable mixtures at various densities, and also from other measurements, that it can only account in small measure for the large differences between the wire and the calculated temperatures.

Apart from the differences between the calculated and the wire temperature curves, there are large differences between the plain wire and the quartz-covered wire temperature curves. For example, the plain wire temperature for the theoretical mixture (29·6 per cent. carbon monoxide and 70·4 per cent. air) is some 400 deg. Cent. above the quartz-covered wire temperature. When, however, the inflammable mixtures are over-rich these differences tend to disappear. For a mixture containing 55 per cent. of carbon monoxide, both the plain and the covered wires yield the same temperature, namely, 1350 deg. Cent. Owing to radiation from the wire, this temperature is somewhat below the real flame gas temperature, but almost certainly not more than about 50 deg. Cent. Assuming therefore that the flame gas temperature is 1400 deg. Cent., we are left with the difference between this temperature and the calculated temperature for the mixture of 1600 deg. Cent. to account for. It may be definitely assumed that there is no incomplete combination (referred to the oxygen of the air), and there is thus a latent energy of the order of 15 per cent. of the heat of combustion left in the flame gases. It will be remembered that the wire temperatures are steadily maintained over a period of time (see Fig. 6), and consequently the latent energy is long-lived.

This long-lived latent energy probably resides in a proportion of the tri-atomic molecules formed during combustion. It may be that in these abnormal molecules an oxygen atom is attached to the carbon monoxide molecule in rather loose fashion, or it may be that the abnormal molecules hold within themselves an excess of intra-molecular energy which cannot be handed over to the translation of degrees of freedom. It is of interest in this connection to point out that Evans and Polanyi[7] have found a similar type of sodium chloride molecule during the combustion of sodium and chlorine. Clearly, if the abnormal molecules hold an excess of intra-molecular energy, or, indeed, if the bond between the carbon monoxide molecule and the oxygen atom is less strong than in the case of the normal carbon dioxide molecule, dissociation of the abnormal carbon dioxide will take place more readily than the dissociation of normal carbon dioxide under similar circumstances. And this is precisely the interpretation to be applied to the quartz-covered wire temperature curve. For such a temperature curve, which has its peak temperature well in the over-rich region, indicates large dissociation. But it must be abnormal dissociation for normal carbon dioxide would not dissociate to any appreciable extent at the temperatures shown by the quartz-covered wire. We have now a complete explanation of the difference between the plain and the quartz-covered wire temperatures. It seems clear that the abnormally dissociated carbon dioxide combines on the plain platinum wire, which, as is well known, supports surface combustion, and so raises its temperature above the true gas temperature. In the case of very over-rich mixtures the excess carbon monoxide suppresses dissociation, and there is therefore no abnormally dissociated carbon dioxide to combine on the platinum wire. Thus both the quartz-covered and the plain wires measure, when corrected for radiation loss, the true flame gas temperatures for very over-rich mixtures. For other mixtures, of course, only the quartz-covered wire measures (after correction for radiation loss) the true flame gas temperature, which is proportional to the mean molecular translational energy.

Interesting support for the quartz wire temperatures is to be found in the soap bubble experiments of Fiock and Roeder.[8] In these experiments mixtures of carbon monoxide and oxygen (containing 3·31 per cent. of water vapour) were exploded in soap bubbles blown at the centre of a hollow sphere, 3ft. in diameter, the initial and final diameters being measured. The explosions were at constant pressure, since the soap film offers very little resistance to the expansion of the gases. Temperatures calculated from the expansion ratios and mixture strengths are shown plotted against the percentage carbon monoxide in the moist carbon monoxide oxygen mixtures in curve T_{SB} in Fig. 8, and for purposes of comparison parts of the quartz-covered wire temperature curve T_Q and of the plain wire temperature curve T_P are also shown, together with the ideally calculated flame temperatures for carbon monoxide and air and moist carbon monoxide and oxygen mixtures. It will be seen that there is a close correspondence between the quartz-covered wire and soap bubble temperatures—all the more so when allowance is made for the fact that there was a large excess of oxygen in the soap bubble mixtures which tended to suppress dissociation. It should be added that when the carbon monoxide oxygen mixtures contained more than 40 per cent. of carbon monoxide the temperatures calculated from the expansion ratios and mixture strengths exceeded the ideally calculated temperatures. The reason for this would

[4] Proc., South Wales Inst. of Engineers, Vol. LI, No. 6 (1936), page 375; *Phil. Mag.*, Vol. XVII (1934), page 172, and Vol. XVIII (1934), page 228.

[5] Except in so far as a slight cooling of the inflamed gases by radiation takes place.

[6] David and Pugh, *Nature*, June 8th, 1940, page 896; and David, Leah, and Pugh, *Phil. Mag.* (in press).

[7] " Transactions," Faraday Soc., Vol. XXXV, Jan, 1939, page 178.

[8] U.S. National Advisory Committee for Aeronautics, Report 532, 1935.

appear to be that such mixtures burnt with great rapidity and the expansions overshot themselves.

Temperatures of Open Flames

We have up to the present been considering flame gases resulting from combustion propagated purely by chain reaction mechanism in which the latent energy is very great. In Bunsen burner flames the flame gases result from combustion which is thermally assisted. Reference to Fig. 3 shows that after the flame front has travelled for

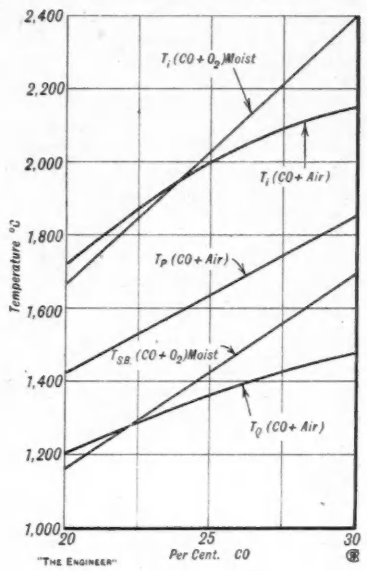


FIG. 8

some distance in the tube it takes on the shape of the inner cone of a Bunsen flame; furthermore, the flame speed (against the moving column of inflammable mixture) may, at any rate for rich inflammable mixtures, be influenced by turbulence. It is to be expected, therefore, that any given inflammable mixture when burnt in the Bunsen burner will result in flame gases which are at a much higher temperature than when burnt during the pre-pressure period in closed vessel explosions.

Most of the open flame temperature measurements have been made by the sodium line reversal method. Many of the sodium measurements are valueless, because of imperfect mixing or stratification of the inflammable mixture fed to the burner,[9] but the same objection does not apply to the maximum or peak sodium temperatures measured for mixtures of any given combustible gas and air. It is believed that these peak temperatures are higher than the true flame gas temperatures corresponding to the main molecular translational energy because the sodium atoms on collision with abnormal molecules may be excited to a higher level than that corresponding to collisions with normal molecules. But for the moment let it be assumed that the peak or maximum sodium measurements do give a reasonably reliable estimate of the maximum true flame gas temperature attained by a mixture of any given combustible gas and air.

The highest sodium temperature ever measured just above the inner cone in a Bunsen flame resulting from the combustion of carbon monoxide air mixtures is 1960 deg. Cent.[10] This is very much lower than the ideally calculated temperature of 2100 deg. Cent., and, making full allowance for radiation loss, indicates a latent energy in the flame gases amounting to at least 7 per cent. of the heat of combustion. Tentatively, it is suggested that the higher the flame speed the greater would be the instantaneous pressure and temperature in the flame front, and therefore the greater would be the thermal assistance which would result in a lower latent energy. Experiments in which part of the carbon monoxide was replaced by hydrogen seem to support this view. In Fig. 9 are shown the highest sodium flame temperatures and the ideally calculated temperatures for mixtures of air and carbon monoxide and hydrogen in varying proportions. It will be seen that with increased hydrogen replacement the flame temperatures approach more and more closely to the ideal, and therefore the latent energy becomes less and less. This correlates well with the flame spectra investigations made by Bone and Weston.[11] These spectra show that the well-known continuous or ill-defined banded spectrum from carbon monoxide air flame gases, which appears to result from abnormal carbon dioxide molecules, tends to disappear with hydrogen replacements.

Pressures Developed in Closed Vessel Explosions

The experiments to be described were made with three spherical vessels of 3in., 6in., and 17·45in. internal diameter. Inflammable gaseous mixtures were introduced into these vessels and were electrically ignited by means of a centrally placed spark gap. Arrangements were made to take continuous records of the pressures developed in the vessels during explosion and subsequent cooling, and at the same time continuous measurements of heat loss to the vessel walls were made by means of bolometers mounted in various positions in the vessel walls. The arrangements were described by David, Brown, and El Din,[12] but improvements have been made in the apparatus and method of calibrating. One of the improvements made may be mentioned. Lewis and Von Elbe[13] criticised the work of David, Brown, and El Din because a small pocket was left under the indicator diaphragm in the 6in. explosion vessel. In the present experiments this has been eliminated, but, it may be stated, that the pocket makes very little difference to the pressures developed, and the work of David, Brown, and El Din has been confirmed in respect of carbon monoxide air explosions.

The maximum pressures developed after explosion (corrected for measured heat loss) in the three vessels when the inflammable mixtures introduced into the vessels consisted of 50 per cent. of CO[14] and 50 per cent. of air at atmospheric pressure, are

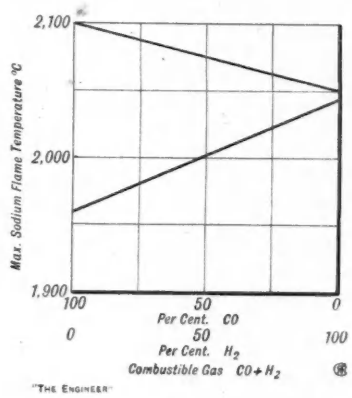


FIG. 9

shown in Table II. This over-rich mixture has been selected for study, for on combustion it results in flame gases in which dissociation is small, and the experimental results therefore lend themselves to fairly simple discussion.

The ideal explosion pressures shown in Table II have been calculated upon the basis of spectroscopic specific heats and dissociation data and the heat of combustion of the CO-air mixtures. The observed pressures have been corrected for

Table II

	3in. vessel.	6in. vessel.	18in. vessel.
Ideal explosion pressure, lb. per square inch ...	109·6	109·6	109·6
Maximum explosion pressure (lb. per square in. abs.), allowing for measured heat loss ...	103·1	104·8	106·7
Latent energy, per cent. heat of combustion ...	7·5	6·0	3·7

measured heat loss from the flame gases. The heat loss from the flame gases amounts to 2·6, 2·4, and 1·8 per cent. of the heat of combustion up to the moment of attainment of maximum pressure in the 3in., 6in., and 17·45in. vessels respectively.

It has been shown that equilibrium conditions have been attained at the moment of maximum pressure, for there is no further evolution of energy.[15] The defect of the explosion pressure (corrected for heat loss) below the ideal therefore indicates that a long-lived latent energy resides in the flame gases after combustion—probably, as has been stated, as an excess of intra-molecular energy within a proportion of the newly formed CO_2 molecules. The amount of latent energy expressed as a percentage of the heat of combustion of the inflammable mixture is shown in the last line of the table.

It will be seen from Table II that the latent energy averaged over the whole of the exploded gases increases as the size of the vessel decreases. The latent energy amounts to as much as nearly 8 per cent. of the heat of combustion in the smallest vessel. Platinum thermometry measurements during the pre-pressure period[16] show that in the gases first burnt after the passage of the igniting spark, it is still greater, as has been shown, of the order of 15 per cent. To some extent this much larger latent energy in the flame gases resulting from the pre-pressure period combustion is due to the fact that the combustion during this period takes place at a much lower pressure (viz., 1 atmosphere) than the mean pressure (viz., about 4 atmospheres), at which combustion takes place during explosion, for experiment has shown that the latent energy decreases considerably as the pressure at which combustion takes place increases.[17] At a pressure of 4 atmospheres the latent energy in the flame gases during the pre-pressure period combustion amounts to about 10 per cent., which is still larger than that measured in the explosions.

In order to account for these results, it is necessary to postulate that the latent energy left in flame gases decreases with the distance of travel of the flame front from the igniting source, and this suggestion fits in satisfactorily with the experiments which have been described in previous sections.

Disappearance of Latent Energy

The latent energy would appear to be unloaded when the flame gases come into contact with surface. Some experiments made a few years ago are of interest in this connection. A weight of 0·67 gramme of thin platinum wire (0·001in. diameter) was loosely bunched in spherical form and suspended inside the 6in. spherical explosion vessel. Continuous records of pressure and heat loss to the vessel walls were made during explosion, and subsequent cooling of a 91·4 per cent. CO and 8·6 per cent. O_2 mixture initially at half atmospheric pressure, first with the bunched wire in position and afterwards when it was removed. The pressure and heat loss records are shown in Fig. 10. The pressures were lower when the wire

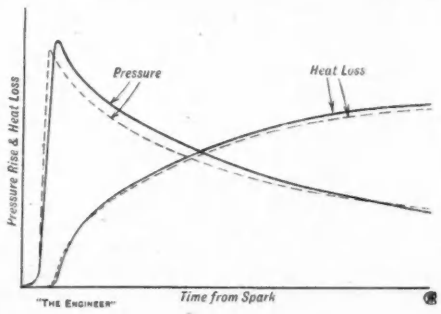


FIG. 10

was in position than when removed until 0·51 sec. after ignition, when they became the same. At this time, therefore, the mean gas temperatures were the same. The heat losses to the vessel walls, as shown by the bolometer records, were almost exactly the same, so that the heat energy left in the flame gases in the one experiment and in the gas plus bunched wire in the other was the same. It would therefore appear that at 0·51 sec. after ignition, assuming the latent energy to have been completely unloaded by the wire, the heat energy in the wire was equal to the latent energy in the flame gases in which the wire was not present. A subsidiary experiment showed that the temperature of the wire was at least equal to the mean gas temperature, as inferred from the gas pressure, and calculation shows that the heat in the wire was approximately equal to 3·5 per cent. of the heat of combustion of the inflammable mixture introduced into the vessel. This compares with the latent energy of 6 per cent. of the heat of combustion estimated from the maximum explosion pressure and heat loss in the vessel with wire removed.

The Canadian Magnesium Industry.—An improved method for the production of magnesium from dolomite has been developed in Canada as the result of lengthy research financed by Bobjo Mines, Ltd., and others, under arrangement with the Dominion Government. A new company is being formed to take over the process.

[9] *Engineering*, March 8th, 1940, page 241.
[10] Jones, Lewis, and Seaman, *J.*, American Chem. Soc., Vol. LIII, 1931, page 3992.
[11] Proc., Roy. Soc., A, Vol. CIX, 1925, page 177.
[12] *Phil. Mag.*, XIV, page 764 (1932).
[13] *J.*, Chem. Phys., 2, page 659 (1934).
[14] 1 per cent. H_2 was included in the CO in the explosion experiments.
[15] *Phil. Mag.*, XXIII, page 350 (1937).
[16] David and Jordan, *Phil. Mag.*, XVII, page 172 (1934).
[17] David and Jordan, *Phil. Mag.*, XVII, page 172 (1934); and David and Leah, *Phil. Mag.*, XXII, page 513 (1936).

Instrument Landing of Aircraft*

No. II

(*Continued from page 256, April 18th*)

EQUIPMENT ON AEROPLANE—INDIANAPOLIS SYSTEM

AS indicated previously, the equipment on the aeroplane consists essentially of suitable apparatus to receive the three types of signals transmitted from the ground and to translate them into such form as will give visual indications to the pilot to direct him in making the landing. The equipment in most common use combines all three indications on the face of one instrument. The cross-pointer instrument was used in connection with the Indianapolis tests, and a cathode-ray type in the micro-wave tests.

On the cross-pointer instrument a vertical needle is actuated by the signals received from the localiser transmitter and a horizontal needle by those from the glide-path transmitter. When the aircraft is on course the vertical needle is in the vertical position, right or left displacement indicating that the aircraft is off course laterally; similarly, the displacement of the horizontal needle above or below horizontal indicates that the aircraft is respectively below or above the glide-path beam. The indications of both needles are such that when the machine is off course either way it must be shifted in the direction of the needle deflection in order to bring it on course.

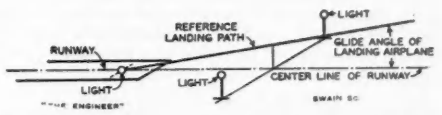


FIG. 6—HYPOTHETICAL ARRANGEMENT OF LIGHTS ON LANDING FIELD

Three indicator lights are operated from the output of the marker beacon receiver. Two of these are used in instrument landing, one to indicate when the aeroplane is over the outer marker and one when it is over the inner marker. The third light shows the pilot when the aeroplane is over one of the fan markers placed at important points along airways or over the towers of the radio range transmitting stations which are equipped with cone-of-silence markers. The marker beacon receiver is in continuous operation during the course of a flight, as it has other important uses in addition to its part in the instrument landing procedure.

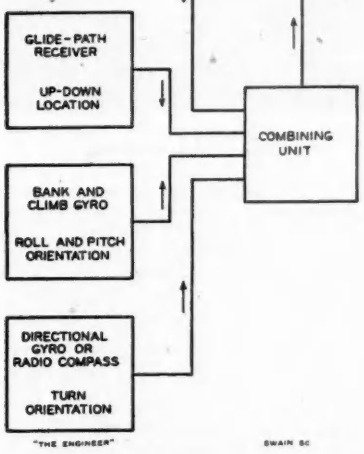


FIG. 7—COMBINATION OF INDICATIONS

One antenna, of the horizontal ultra high-frequency loop type, receives both runway localiser and glide-path signals. A horizontal di-pole antenna mounted underneath the aeroplane receives the marker beacon signals.

Both localiser and glide-path receivers are crystal-controlled fixed-frequency super-heterodyne units. The localiser receiver is equipped with automatic volume control. To assure satisfactory operation under varying conditions the glide-path receiver is provided with a voltage regulator, a ballast lamp and temperature-sensitive elements.

The marker beacon receiver also is a crystal-controlled fixed-frequency super-heterodyne unit and is arranged for both visual and aural indication of the signal being received. Three filters in the receiver separate the 400 and 1300-cycle modulating tones of the instrument landing system and the 3000-cycle tone of the fan and cone-of-silence markers.

EQUIPMENT ON AEROPLANE—MICRO-WAVE SYSTEM

In developing a suitable instrument for the micro-wave system to be installed on the aeroplane, the problem was considered as illustrated in Fig. 6. If under conditions of no visibility it were possible to present to the pilot the same information that he would obtain were he to land on a clear night by means of three lights arranged on the landing field as shown, then a serviceable instrument landing system could be realised. These lights would indicate to the pilot in a simple, natural and continuous manner not only the location, but also the attitude and heading of his aircraft.

This conception of the problem is due to Dr. Irving Metcalf, of the Civil Aeronautics Authority, and is responsible in part for the undertaking of the micro-wave instrument landing research by M.I.T., in that it demands much greater precision in the location of an approach path than appeared possible with the then existing glide-path systems.

To visualise the problem in greater detail imagine that the three lights are seen through a transparent screen in front of the pilot. Assume that the screen has vertical and horizontal crosshairs intersecting at its centre. When the aeroplane is in the proper orientation for landing, and is on the reference landing path defined by the three lights as shown, the pilot sees these lights equally spaced along the horizontal crosshair, the centre light coinciding with the centre of the screen. Any departure of the lights from this pattern on the screen indicates a corresponding departure of the aeroplane from the proper location or orientation.

In the simplest interpretation the location of the light group indicates orientation and the relative configuration of the lights as a group indicates location. Thus, turning of the aeroplane to the right or left moves the lights as a group left or right respectively; moving to the right or left of the reference landing path moves the image of the centre light nearer to the image of the right or left-hand light, respectively.

In the instrument developed the cathode-ray tube is used to provide the indications. Information regarding orientation is derived from gyroscopic instruments on the aeroplane; information regarding location is derived from the radio beams transmitted from the ground. The various indications are combined as shown in Fig. 7, and through a mechanical commutating device are impressed in rapid succession on the deflecting plates of a single-gun cathode-ray tube so as to give the visual appearance of a stationary pattern on the screen of the tube.

To obtain suitable indications from the gyroscopic instruments required the development of a simple electrical take-off. Voltages thus obtained from the gyro instruments are sufficient to deflect the spots on the cathode-ray tube directly, and therefore amplifiers are not necessary.

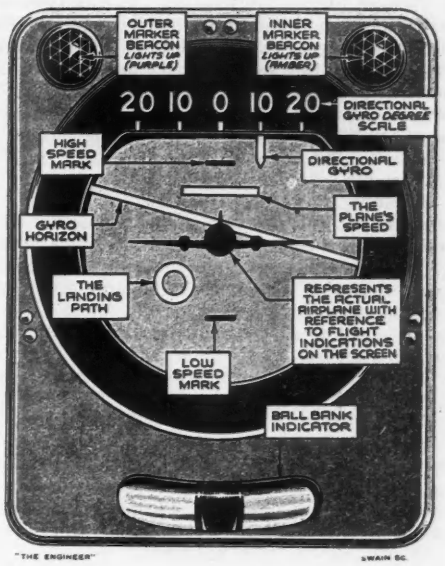
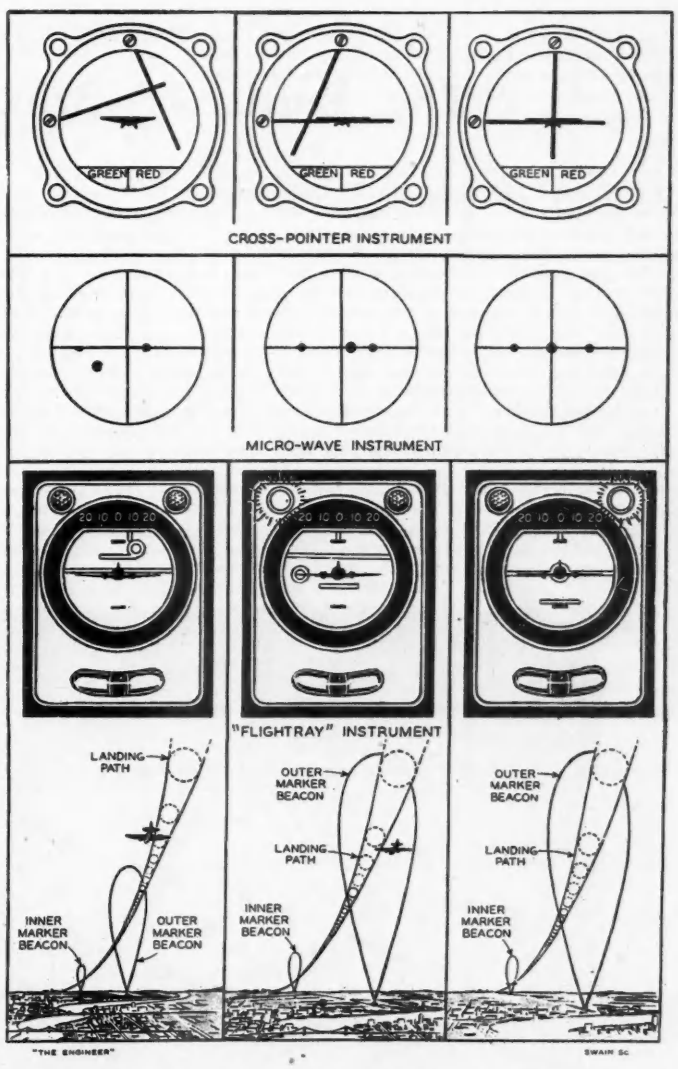

OUTER MARKER BEACON LIGHTS UP (PURPLE)
INNER MARKER BEACON LIGHTS UP (AMBER)
20 10 0 10 20
DIRECTIONAL GYRO DEGREE SCALE
HIGH SPEED MARK
DIRECTIONAL GYRO
GYRO HORIZON
THE PLANE'S SPEED
THE LANDING PATH
REPRESENTS THE ACTUAL AIRPLANE WITH REFERENCE TO FLIGHT INDICATIONS ON THE SCREEN
LOW SPEED MARK
BALL BANK INDICATOR
"THE ENGINEER"
SWAIN SC

FIG. 8—FACE OF FLIGHTRAY INSTRUMENT

The ultra high frequencies used necessitated the development of special equipment to receive the



Separate signal lights associated with the cross-pointer and micro-wave instruments indicate when the outer and inner marker beacons are passed.

Left: Pilot is starting an instrument landing; aircraft below and to left of glide path.

Centre: Aircraft off path to right and beginning to descend; also passing outer marker beacon.

Right: Aircraft on glide path and passing inner marker beacon; has but about one-half mile to airport runway.

FIG. 9—TYPICAL INDICATIONS ON THE THREE TYPES OF INSTRUMENT

* Reprinted from *Electrical Engineering*, December, 1940; published by the American Institute of Electrical Engineers.

glide-path signals on the aeroplane. The received signal goes directly into a converter, which mixes the signal with the third harmonic of the local 230-megacycle oscillator, producing a 10-megacycle beat-frequency signal. The beat frequency is fed to the intermediate-frequency amplifier, where it is amplified with no greater difficulty than any other 10-megacycle signal. In the tests an elaborate audio-frequency amplifier followed the super-heterodyne receiver proper, incorporating four stages of resistance-coupled amplification with automatic volume control, a separating filter for 90 and 150 cycles per second, and separate one-stage amplifiers following the filter. The output of this audio unit is fed to the adapter unit of the cathode-ray indicator.

A control is provided to allow adjustment of the relative gain of the two audio channels. The setting of this control determines the angle of the glide path with respect to the ground, and the control may be set so that the approach path angle is correct for a given type of aeroplane. This arrangement does not require a readjustment of the ground station to set the glide angle. The antenna is of the coaxial type, connected to the receiver by a ¼in. copper coaxial line.

The cathode-ray indicating instrument also is useful during flight, the runway localiser signals being replaced by radio beacon signals. It can be applied also to other landing systems; likewise, the micro-wave glide-path and localiser equipment can be used with other indicators, such as the conventional cross-pointer instrument.

The Flightray

Another cathode-ray instrument, developed by the Sperry Gyroscope Company for both instrument flight and landing, is known as the Flightray (Fig. 8). When used in making instrument landings, the localiser landing beam is arranged to control the horizontal position of the landing path circle and the glide-path beam the vertical position. In flight, the horizontal position of the circle is controlled by the flight course radio beacon, and the vertical position by a barometric altimeter. In either event the aircraft is on course when this circle rings the fuselage of the miniature aeroplane outline in the centre of the screen.

Altitude information is obtained from the gyroscopic instruments by means of simple electromagnetic pick-ups. As a knowledge of speed is important in making an instrument landing, an indication of the aeroplane's speed also is provided, by a short horizontal line, the position of which varies vertically between two limit marks on the screen. When this horizontal line approaches the low-speed mark the pilot knows that his machine is approaching its stalling speed.

The position of the miniature aeroplane outline painted on the screen of the cathode-ray tube indicates the position of the aeroplane with respect to each of the four indications. When the aeroplane is off course in any direction it need only be flown toward the particular pattern to bring it back on course. Signal lights above the cathode-ray tube indicate when the machine passes over the outer and inner markers, one indicator for each marker.

As there are four separate indications on the face of the cathode-ray tube, switching is necessary, as with the instrument used in the micro-wave tests. To accomplish this the various amplifiers associated with each instrument pick-up are sequentially made operative by means of a commutator which applies suitable control voltages to each amplifier in turn. As with the micro-wave system, commutation takes place at a rate well above the persistence of human vision, with the result that although only one line is shown at a time the composite pattern is entirely free from flicker.

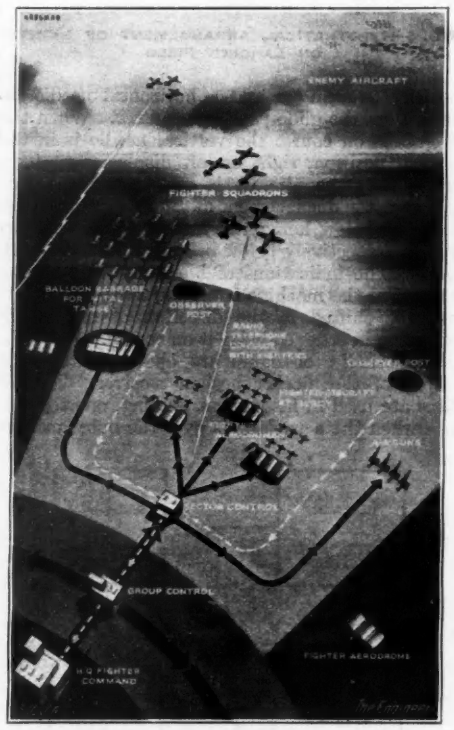
In Fig. 9 diagrams are given showing typical indications on the three types of instrument described above.

"The Battle of Britain"

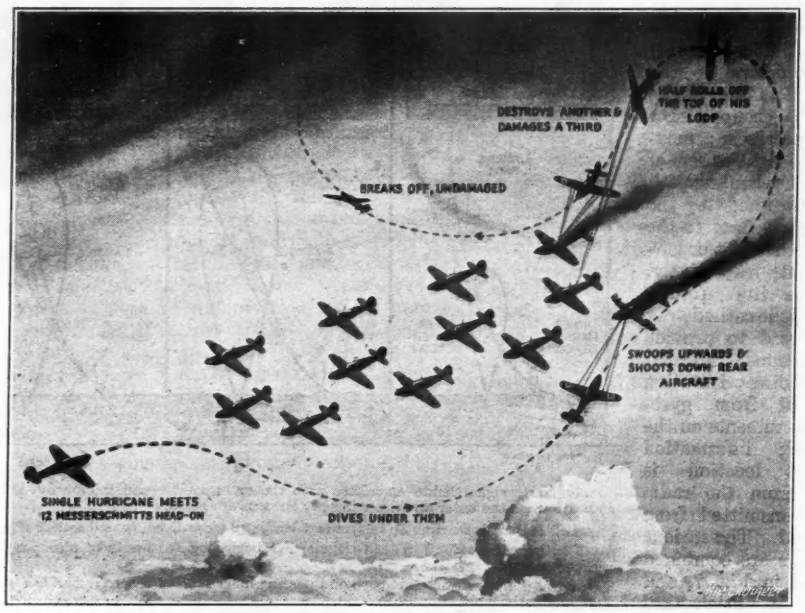
NEARLY two million copies have now been printed of the first edition of "The Battle of Britain," the Air Ministry account of the great days of air fighting over this country from August 8th to October 31st, 1940. Few of our readers will have failed to read it, but many of them may be glad to know that a second edition, accompanied by illustrations, has now been published by His Majesty's Stationery Office. The illustrations, consisting of diagrams and reproductions of photographs, add very considerably to the understanding of the text, and to the human interest of the narrative. At first reading, the original unillustrated edition left a certain confusion in the mind concerning the course of events. That confusion was, no doubt, to be traced to the fact that the rapidity with which an air battle is fought, the great extent of the space which it covers, and the individuality of the incidents which compose it, do not lend themselves to reproduction and explanation by means of a series of plans, such as those employed by historians to depict a land battle or a naval engagement.

Nevertheless, in the new illustrated edition an attempt has been made with very considerable success to present by means of three maps three of the four phases of the enemy's air assault on this country during the months of August, September, and October last year. The first phase, lasting from August 8th to August 18th, was one in which the Germans made an all-out bid for total victory. Their plan was clearly to secure command of the air over London and the Home Counties by attacking our fighter stations in the Dover area, and those farther inland to the south of the Thames. The second phase lasted from August 19th to September 5th. During it the attack moved inland and was directed against fighter stations north of the Thames, which had not previously been assaulted. On August 24th it was already evident that the R.A.F. was mastering the enemy. On that day a force of 110 German bombers and fighters, coming in over the coast near Rye, penetrated as far as Tonbridge, then turned tail and fled back home before they could be engaged. The third phase lasted from September 6th to October 5th. The whole strength of the enemy was flung against the London area, the fighter stations being passed over. One day perhaps we will learn whether this third phase was launched as part of a preconceived rigid plan from which the enemy was unable or unwilling to depart, or whether it was a fundamental change of tactics dictated by the hard hammering which the *Luftwaffe* had suffered during the previous month. By September 6th our fighter stations ought to have been out of action all round London, and the way should have been open for attacks by day and night on the London area. As all the world knows, the enemy struck his head violently against the still undiminished might and daring of our fighters. The "greatest day," Sunday, September 15th, fell within this phase. It, no doubt, represented what the enemy intended should be the final assault on our defences. Five hundred aircraft were sent against us on that day. They were savagely handled by our "Spitfires" and "Hurricanes," so savagely that, counting only certainties, 185 enemy machines were destroyed, roughly at the rate of two a minute of actual fighting time.

As an example of the tactics employed by our fighters in their individual engagements with groups of enemy aircraft, we reproduce one of the diagrams given in the new edition of "The Battle of Britain." It is self-explanatory, and shows how a single "Hurricane" accounted for three out of a group of twelve Messerschmitts. The second diagram which we reproduce will give some idea of the organisation of our defences, an organisation without which all the daring and skill of our pilots would in all probability have failed to achieve the decisive defeat of the enemy.



OPERATIONS CONTROL


DESTROYS ANOTHER & DAMAGES A THIRD
HALF ROLLS OFF THE TOP OF HIS LOOP
BREAKS OFF, UNDAMAGED
SWOOPS UPWARDS & SHOOTS DOWN REAR AIRCRAFT
SINGLE HURRICANE MEETS 12 MESSERSCHMITTS HEAD-ON
DIVES UNDER THEM

ONE HURRICANE VERSUS TWELVE MESSERSCHMITTS

Time will show whether or not the title of this pamphlet has been correctly chosen. It is too early to say whether the great air engagements of last autumn will constitute the real Battle of Britain, or whether they will prove to be the first phase of the enemy's efforts to subdue us. Even now the Battle of the Atlantic can be seen as the second phase, and the time may soon come when a military phase will be upon us. But, however historians will record it, the Battle of Britain will always be regarded as having begun on August 8th, 1940, when the enemy opened his air attack on this country by heavy bombing raids against our convoys off the Isle of Wight and Bournemouth. If they do not find it

possible to write that it ended on October 31st, 1940, they will at least be able to say that without the skill, tenacity, and courage of our pilots last autumn we would have been given little chance to continue the struggle to a victorious conclusion.

Selection and Training of Apprentices — Practical Training*

By E. D. RUSSELL†

In an industrial country such as our own, where the livelihood of the nation depends to such a large extent on its productive capacity, the importance of a well-trained labour supply is universally recognised. Whether the individual be bench hand or manager, it is of vital importance that he should be properly trained for his job, and as apprentices are the main nucleus of such labour supply it is impossible to stress too strongly the importance of training them so that they may meet the needs of industry most fully; not only that they may be capable of a high productive output, but also that they may be capable of appreciating the difficulties of other trades, and of the managements of the firms by whom they are employed.

Much time and thought has been devoted to the subject of scientific management, by which is meant the study of different methods of production, motion study, reduction of effort, &c.; but it is not always appreciated to a sufficient extent that the training of personnel is an equally important branch of scientific management. When efforts are made to change methods of production it is usually found that one of the main difficulties encountered is to persuade employees—particularly older employees—to alter methods that have served them well for many years, and to persuade them that the new ideas which the management is endeavouring to incorporate are better and more likely to result in a higher output. This conservative outlook of the average workman is evidence of the fact that the methods of training personnel have not kept pace with the advances which are being made in the fields of design and production. It will usually be found that, while the average workman is able to appreciate the advantages and good points in a new design of article, when viewed from the purely engineering standpoint he is not so capable of seeing the advantages to be obtained in the finished article from altering his own methods of carrying out a particular job. This infers that while we still produce as good engineers and shipbuilders as ever, our workers are not as adaptable as modern conditions require, and suggests that methods of training personnel require serious overhaul in order that they may produce men more fitted to the conditions prevalent in industry nowadays. To a certain extent this has been attempted by many firms engaged in the lighter branches of engineering, and strangely enough those engaged in mass-produced articles, such as motor-cars and electrical equipment, &c., where less skilled labour is required, but it cannot be said that the same efforts have been made in the heavier branches of engineering or in shipbuilding.

Formerly, when workshops were smaller and the pace of industry slower, it was customary to place the apprentices under the immediate care of the shop foreman or of one of the senior workmen, who acted as a kind of apprentice instructor or supervisor. This man, who was in most cases a thoroughly skilled craftsman, was able to devote to the apprentices the care and attention which they needed, and was able to show to them by personal tuition the various and best methods of carrying out the operations involved. Thus, the apprentice was carefully coached through progressive stages until at the end of his five years' apprenticeship, when he reached the status of journeyman, he could really claim to have had a very thorough grounding in his trade. This system can only be employed, however, where the foremen or leading hands have a reasonable amount of spare time during working hours, which time may be devoted to instructing the apprentices. It must always be remembered that the new apprentice, probably fresh from school, is seldom fit to be left on his own, but requires personal attention and tuition during the early stages of his training.

In the present times, however, when everybody is working to full capacity, few foremen (even with the best intentions) have either the time or the opportunity to devote to their apprentices the attention which they know is necessary. The result is that the apprentice, who is usually started at the age of sixteen, serves a five years' term, at the end of which time he is classed as a journeyman, quite irrespective of what he may have learned or of how skilled he may be. In too many cases the new apprentice, when he first starts, is put to work with the first journeyman who needs an assistant or a helper and for months merely fills the *rôle* of odd job boy between spells of idleness. Thereafter he is moved around from one man to another and for the first year or so his movements are determined solely by the needs of the men for assistance and not according to any pre-arranged or well-defined plan. This is a most dangerous procedure and one very likely to encourage a lazy outlook, since we find that the boy at the very stage when he is most in need of strict control is left too much to his own devices to find means of occupying his time. With apprentices fresh to industrial life, it is essential not only that they be kept busy, but also that such tasks as they are given to perform be of an interesting and instructive nature. If this is not done, most of the boy's initial keenness for his job will be lost.

What, then, is to be done to put the training of apprentices on a sound basis? First, it would seem advisable in all industrial establishments, particularly those in which there is a large number of apprentices, that the training and welfare of these apprentices be put under the care of a trained and responsible supervisor and that their training, for the first two or three years at least, should follow a definite pre-arranged course. During the later stages of his apprenticeship the course could be adjusted to suit the boy's capabilities. This course, the nature of which would, of course, be determined by the needs of the firm concerned, should aim at producing not merely a trained specialist craftsman, but should be devised in such a manner as to give the man a superficial knowledge of other trades, in order that he may appreciate the difficulties of these trades and may see his work as part of the finished whole and not just as a small individual operation.

In many of the larger firms where definite systems for training apprentices are practised, the apprentices are first put into either a training school or training section, where they are given a grounding in the work of the factory and do small odd jobs. By this means they develop a certain manual dexterity, become acquainted with the various machines used, and in general get a rough idea of what working conditions are really like. After spending a few months in this department they are sent out to the main factory and are put into first one department and then another so that they receive a kind of superficial training in the various branches of the work. This gives both the apprentice and his employer an opportunity to weigh up the boy's capabilities and gives them a basis upon which to decide the trade for which he is best fitted. It is possible that were this procedure adopted in the heavier branches of engineering, namely, structural and marine engineering and in shipbuilding, that opposition would be encountered from the trade unions. However, for the benefit of the industries generally these difficulties should be overcome by some means or another.

* Abstract from one of three papers read before Institution of Engineers and Shipbuilders in Scotland, April 8th, 1941.

† William Denny and Bros., Ltd.

American Engineering News

Earthquake Resistant Tower

With a selected site only 2 miles from a major geologic fault, which is active in earth movements, it was necessary to include earthquake resistance as a serious factor in the design of the building for the Hoover Library of War and Peace at Stanford University, in California. From a relatively small rectangular base, 122ft. square and three stories high, rises a sixteen-story tower, 280ft. high, and the problem was the earthquake resistance of this tower. It is 53ft. square at the base, and tapers slightly to the fourteenth floor, above which it is octagonal, and finally surmounted by a dome above the sixteenth floor. As the structure will be used mainly for book stacks and racks, and will be air conditioned, no windows are provided, except in the office section on the eleventh floor. This feature facilitated the introduction of diagonal bracing with consequent reduction in the columns and girders. While the tower framing is of steel, it is enclosed by walls of reinforced concrete, designed to resist earthquake shock, the steel frame being braced to resist wind loads only. The three-story structure has a continuous foundation under the walls, and independent footings for its interior columns. A separate foundation for the tower consists of a reinforced concrete slab, 61ft. square and 6ft. thick. The concrete walls of the tower are 12in. thick up to the fourth floor, above which they are 8in. thick, with exterior pilasters, 12in. thick. While the designing of the structure was complicated by the provisions for earthquake resistance, the construction work and the cost were increased to only a small extent by these provisions. In the lower four stories the principal features specially relating to earthquake resistance are an additional thickness of 12in. for the walls, extra thickness and reinforcement of columns and walls, and extra thickness of roof around the tower. In the tower itself the only features for this purpose are heavily reinforced piers at the eleventh floor level to carry shear and bending stresses resulting from earthquake shocks.

Eight-coupled Passenger Engines

While eight-coupled locomotives have been used on a number of American railways, they have been confined mainly to sections having heavy gradients. It is of interest, therefore, to note their introduction on the New York Central Railroad, whose line is one of very easy gradients. Of fifty new engines of this class—4–8–2—half are for fast and heavy passenger service and the others for freight service. In the former service they have given performance equal to other engines with much larger driving wheels—6ft. 7in. For high-speed running, light-weight alloy metals have been used extensively in the revolving and reciprocating parts. All driving axles are of vanadium steel, hollow bored and with roller bearings. Instead of the almost universal Walschaerts valve motion the Baker motion is used. Although the tenders are very large and carried on six-wheel bogies, the size is mainly for coal capacity, as the line is equipped with track tanks. Some of the main dimensions are as follows:—

Cylinders	25½in. by 30in.
Driving wheels	5ft. 9in.
Leading bogie wheels	2ft. 9in.
Trailing bogie wheels	3ft. 8in.
Wheel base, driving	19ft.
Wheel base, engine	43ft.
Wheel base, engine and tender	96ft.
Weight on drivers	130 tons
Weight on leading bogie	35 tons
Weight on trailing bogie	28 tons
Weight of engine	193 tons
Weight of tender, loaded	185 tons
Boiler, diameter	7ft. 10in.
Fire-box	10ft. by 7ft. 6in.
Combustion chamber, length	7ft. 6in.
Tubes, length	20ft.
Grate area	75·3 square feet
Heating surface, fire-box and combustion chamber	375 square feet
Heating surface, tubes	4282 square feet
Total evaporating surface	4657 square feet
Superheating surface	2080 square feet
Boiler pressure	250 lb.
Tractive force	60,100 lb.
Height overall	15ft.
Main driving journals	12⅞in. by 14in.
Other driving journals	11in. by 13in.
Fuel, bituminous coal	43 tons
Water	15,500 gallons

Sixty Years Ago

Engineers in the Navy

A few weeks ago we summarised in this paragraph a leading article in which we had expressed our views concerning the claims of engineers in the Navy to better treatment and improved status. Although, naturally, we expressed sympathy with and interest in the engine-room staffs of naval vessels, we wrote very frankly regarding the nature of their work and the merits of their claim to be considered as officers and gentlemen. In brief we said that the work of a naval engineer could not be considered as professional, that it did not justify the granting of officers' commissions to those performing it, and that it ought to be left in the hands of mechanics rather than of highly trained engineers. A second leading article on the subject appeared in our issue of April 29th, 1881. Our earlier article had been reprinted in other journals and had received wide publicity. The naval engineers did not like the views we expressed and their wrath descended upon us. In our second article we held fast to our views. We reminded our critics that in the early days of steam power in warships the engines were merely auxiliary to sails and were regarded by seamen, not without justice, as an unmitigated nuisance. The men in charge of the engines were not "officers and gentlemen," but just hard-working, competent artisans, mostly from Scotland, who knew how to keep their engines and boilers in good order. As the engines became more and more important a superior class of men entered the service as engineers. In time the Government made officers of them, but their pay and social rank were inferior to those of the executive officers. They resented their inferior position and appealed to Parliament and the country for improved treatment. The Government took what we believed to be an unfortunate course in dealing with the situation. It introduced a new class, the engine-room artificer, into the Navy to do the upkeep and repairing work of a mechanical nature, leaving the engineers to act in a supervisory capacity. It was hoped that by this course men of education and high engineering attainments would be attracted to the Service. That hope was disappointed and in due course the Government established the Naval Engineers' Training College to ensure the supply of men of the requisite character and technical standard. We maintained that naval engine-room service did not and never would provide the basis of a profession, that it was a mechanic's job, and that to place it in charge of men who thought chiefly of keeping their uniforms clean was wrong in policy and might lead to disaster in practice. . . . We need hardly add that the views on this subject which we expressed sixty years ago are not those which we hold to-day.

An Alloy by Sintering.—Reviewing engineering progress in 1940, the *General Electric Review* claims that the production of alnico, a permanent magnet alloy, by means of sintering instead of casting, is only one more step in a long series of advances in the field of powder metallurgy, starting with the preparation of ductile tungsten by the sintering of tungsten powder, and going through the development of the so-called oilless bearings and the hard cemented-carbide tool materials. The technique of alnico sintering requires the high-temperature diffusion of four or five metal powder constituents into a homogeneous alloy, the process being carried out in an atmosphere of dry hydrogen. The sintering of other metals besides alnico is now receiving attention.

The Engineer

APRIL 25, 1941

VOL. CLXXI No. 4450

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EIGHT PAGE SUPPLEMENT—"THE METALLURGIST"

NOTICES TO READERS

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The Metallurgist.

THE APRIL NUMBER OF
THE METALLURGICAL SUPPLEMENT TO
"THE ENGINEER" ACCOMPANIES THIS ISSUE.

THE TRAINING OF APPRENTICES

UNDER the stress of war production, there has developed in this country a great shortage of skilled labour in almost every trade. It is, in fact, a lack that is confined not solely to these islands, for our enemies, too, feel the deficiency, and soon, as her production rapidly mounts, the United States will feel it also. Apologists may argue, and argue truthfully, that in time of war there never are likely to be sufficient skilled hands to meet the demand. Yet, even though that be admitted true, there can be little doubt that had we in this country done more in pre-war years to encourage the training of labour and had fewer firms depended only upon the labour market for skilled hands instead of setting up their own apprenticeship schemes, we should not now feel our lack so keenly. It may be added, too, that were all apprenticeship schemes as well devised and as well operated as those of a relatively small number of firms, there would not now be among the ranks of the "skilled" so many of those who, though five years apprenticed to a trade, are yet unworthy of their wage—the pseudo-skilled.

Many differing systems of training apprentices were in operation among the firms of this country when the war broke out. Some depended only upon that traditional method, successful in the past, of assigning a newcomer to the mercies of a journeyman or a succession of journeymen, who might or might not trouble to teach him his trade. Others operated schemes more or less fully developed, such, for instance, as that recently described by C. A. Packer in one of three papers in a symposium on "The Selection and Training of Apprentices," recently read before the Institution of Shipbuilders and Engineers in Scotland. There is thus no agreed plan, no formal syllabus for the training of apprentices, nothing that is in the least akin to the similarity between college courses, and not even a universal examination standard that must be reached before the post-apprentice may regard himself as qualified. But is such homogeneity desirable? It is, we think, of greater importance that apprentices shall be trained according to some definite plan than that the plan shall be exactly the same as, or even similar to, those of other firms. For if the foremen be interested and be able to spare the time, and if the right journeymen be selected under whose tuition to place an apprentice, the traditional method of training is as capable of producing fine skilled hands as any modern scheme. Hard-and-fast rules cannot be laid down for the training of apprentices. Much depends, for instance, on the kind of work carried out in the shops of the firm concerned. Differences clearly must exist between apprentice training schemes suitable for such diverse industries as shipbuilding, locomotive construction, heavy electrical plant, and general light engineering. The important thing, it seems to us, is to make a plan for training apprentices, and see to it that it is properly carried out. The question as to which are the better methods of training is one which is too involved to provide an easy answer, so that provided an apprenticeship scheme be well conceived and sufficiently flexible to provide for modification, it is as likely to be very good as any other.

On another page of this issue we reprint in abstract form one of the papers from the symposium. It was read by Mr. E. D. Russell, and the section which we print does not deal with any particular scheme of apprenticeship, but consists of a consideration of some of the factors influencing the success or failure of a system. His remarks, we can believe, met with general commendation at the meeting. Yet surely he made one serious omission. His ideas for the training of apprentices are conceived more particularly with the intention of creating skilled journeymen as quickly as may be possible. But it is of at least equal importance that each apprentice in going through the works should develop that rather mysterious quality "character" that is so hard to define. Of that, Mr. Russell makes no mention. Whether training can inculcate "character" is, indeed, a questionable matter. That is a problem which even the so-called science of psychology has so far failed to solve. But whatever the truth upon that score, it is certain that much can be done during apprenticeship by encouragement and sympathy to hasten its development. No apprentices training scheme can really be regarded as satisfactory unless its originators bear that fact in mind.

Road and Rail Once More

Is any excuse necessary for returning at this time to a discussion of the condition of road and rail transport after the war is over? Admittedly the first thoughts of all in this country must be directed to the matter of bringing the war to a successful conclusion. Yet, though in the international field we may feel bound to discuss peace aims only in the most general of terms, it would be foolish were we not to give consideration in some detail to the conditions likely to prevail in this country when Nazism has been extirpated and peace reigns over Europe once more. In the matter of transport within this country a truce has been enforced "for the duration" by the Government, and the opportunity thus exists to examine the whole matter with blood unheated by the effects of rivalry. Such consideration of the subject becomes more urgently necessary the nearer our approach to victory. For by the end of the war, to judge by the effects of the 1914–18 affair, the railways will be in no condition, at least for some years, to resist acute competition; whilst should a host of surplus Army lorries be released upon the market, one-man road haulier businesses might multiply and indulge in mutually self-destructive competition. The danger of such chaos is so clearly obvious that no one doubts that such conditions will not be permitted to arise. But what is wanted is not mere preventive legislation. Rather it is the development of some constructive policy which will allow the railways and the road transport organisations to develop side by side to the mutual advantage of themselves and the whole country.

The trouble about road-rail competition has always been, however, that while fine principles can be enunciated as to the state of affairs that should exist, it is very difficult indeed to translate those principles into practice. All would agree "that national transport policy should be based on the general interest and directed to the well-being of the community," as General Sir H. Osborne Mance enunciated it in a recent paper before the Institute of Transport. Few would disagree with a subsequent sentence. "It follows that the interest of individual users or providers of transport should be subordinated to the public interest, remembering that a healthy transport industry is fundamental to the national welfare." The trouble begins when it is attempted to define what such principles mean when translated into legislation. For the characteristics of the two forms of transport are so very different that it is difficult to find common ground on which to work, whilst at the same time they are able to compete for a very wide range of traffics. Many proposals have been made for the regulation of road and rail transport. Few would now be found to support any suggestion for unrelieved competition. Besides other disadvantages it leads inevitably to greater and greater inefficiency as the contestants become increasingly impoverished. Nor is Government ownership or the monopoly of a single concern controlling both road and rail haulage any more attractive. Though it certainly has the merit that goods would be sent by that method of transport which involved the least cost of carriage, it would be bound to suffer all the well-known disadvantages of monopoly, including lack of initiative and "drive," so that before many years had passed it would be likely to become a financial burden on the State. Other proposals have attracted more adherents. Suggestions have been made that traffics should be allocated by classes to those forms of transport considered best suited to their carriage; or that the length of haul should be the deciding factor. General Mance has himself put forward an interesting proposal for the pooling of certain costs, a plan the details of which it would take too much space to discuss here and the practicability of which remains in doubt. But to all of these three schemes there appear to be serious objections, whilst only that of General Mance can be said to be based on anything like fundamental principles.

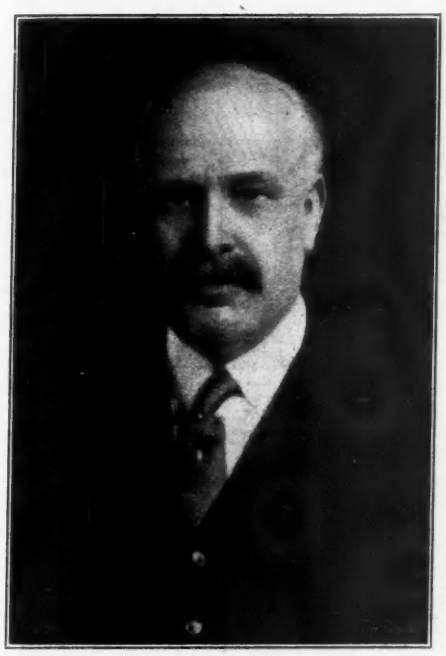
We have no proposal to put forward here ourselves. The point we wish to make is that any legislation after the war should be based on some more fundamental conception of the relations that exist between the various forms of transport than has heretofore been apparent. For the problem of competing forms of transport is not confined only to the rivalry between road and rail. Far from it. When peace returns the claims of canals and coastwise shipping will also demand consideration, whilst it is possible, even perhaps probable, that even in so small an island as ours air transport in the first few peace years will begin seriously to compete with older forms. Unless the relations of all forms of transport—road, rail, canal, sea, and air—are put upon some equitable established basis we may well find after the war the canals falling back into desuetude, the railways again at loggerheads with road hauliers, and all voicing a new complaint against competition from the air.

Obituary

LORD STAMP

WERE we to say that Lord Stamp, whose death by enemy action we mourn, was the greatest financial economist of his day, we should be at once reminded of two or three other men who might challenge that distinction. But if we say that he was the most widely known, that will perhaps be accepted. He had a reputation as a lecturer, and, as is common in such cases, many people went to hear the man though they could not understand the matter. In truth, he was often not easy to follow, and some of his addresses are more suitable for the study than the platform. He was a conventional economist—at least, we cannot recall any novel financial proposals being advanced by him. But he was conventional as a chess master may be conventional. That was no doubt why he became a Director of the Bank of England and why he was so frequently consulted by the Government on financial questions.

But it is with Lord Stamp as President of the Executive of a great railway that we are principally concerned. It was in 1925 that the directors



LORD STAMP

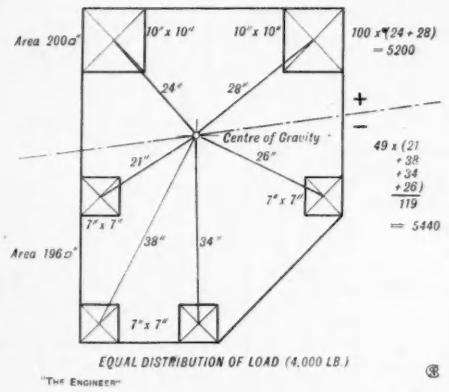
of the London, Midland and Scottish Railway invited him to set their house in order for them. Their system, like others, was in difficulties. Grouping had introduced many problems, and a master mind was needed to grapple with them. Sir Josiah—as he was then—re-formed the whole organisation. He called himself President, and to aid him on the technical side appointed several Vice-Presidents. Sir Guy Granet was then Chairman of the company. This action met with a storm of criticism. To railway men it was bad enough that a man who had no connection with railway operation should be set over them; it was worse still that he should break away from the traditional British form of management and introduce a system and nomenclature that smacked of the western hemisphere. Unperturbed by the hullaballoo that he had caused, Stamp pursued his way, and by dint of hard work and an engaging manner put the affairs of the L.M.S. in order and won the respect, even the affection, of railway men. He was Chairman of the company at the time of his death.

There are walks of life in which indifferent health does not mar success. But the reorganisation of a great railway system is not amongst them. A sound body is as necessary as a sound head. Stamp had both, and, moreover, he was at the prime of his years; he was born in June, 1880. He was tireless, and to the best of our knowledge he was never perturbed. If there were difficulties to be surmounted, he had the strength to surmount them, and enjoyed using it; they did not upset him, but only offered him a new outlet for his energy. Only Heaven and "Who's Who" know how many boards, committees, and councils he sat on, and in how many ways and in what a variety of directions he served his country. He began his career in the Civil Service, and though he retired from it years ago, it may truthfully be said of him that to the end he was in the service of the public. We can ill spare a man of his calibre with another decade of useful life before him. Our enemies hit us hard when they killed him.

Cork Insulation for Machine Bases

EXPERIENCE as well as theoretical reflections have shown that the insertion of some resilient matter between a vibrating machine and its base will form an efficient bar against the propagation of vibrations into the surroundings, and it has become engineering practice to isolate machines by mounting them on cork pads. If a set of machines requires a common bed-plate the cork is inserted between this and the ground or the floor on which the set is to operate. Specifications sometimes prescribe cork pads of 2in., or 1½in., or 1in. in thickness. Mostly natural cork wood is used cut to suitable sizes and held together by an iron band (ironbound cork) or by a suitable glue.

Foundations of this kind present two tasks to the designer—the purely statical of distributing the load equally on the pads, and keeping the pressure per unit area within certain bounds prescribed by the nature of the material. This pressure should not exceed 10 lb. per square inch. The second task is one of dynamics and consists in determining the resiliency required to prevent the spreading of the vibrations. By



TYPICAL ARRANGEMENT OF CORK PADS

dividing the entire load, consisting of the weight of the set and the raft by the specific pressure of 10 lb. per square inch, the entire area of cork required can be determined. The distribution of this area among the different pads is easy in all cases where the set has two axes of symmetry as the pads can be placed symmetrically to those axes in the corners of the raft. If thereby the span between two pads should become too large, the pads must be subdivided and one or more smaller pads must be placed in between.

When the weights of the different parts overlap this simple method does not apply and the centre of gravity must be determined. This is easy as most engineering firms know the centre of gravity of their machines and will give the necessary information. The size of the pads must first be assessed, making them larger near the centre of gravity and smaller at a greater distance. For checking the result a line can be drawn through the centre of gravity which does not touch any of the pads, and taking all areas of the pads on one side of the line as positive and on the other side negative, all products $a \times r$ should be added. Here a stands for the area of the pad and r for the distance of its centre from the centre of gravity. The sum should be equal to zero, as the centre of gravity is the point for which $\Sigma a \times r = 0$. Small deviations from this rule can be neglected as the figure of 10 lb. per square inch as the optimum specific load for the cork allows of a certain variation. An example is shown in the accompanying diagram.

The effectiveness of a foundation of this kind from an isolation point of view will naturally depend upon the resiliency of the pads of cork employed. A simple calculation will show up the limits. If an insulation of this kind is to be effective the natural frequency of the entire system consisting of the set and the raft should be one-half—better one-third—of the frequency impressed by the machine while operating. For all rotating machines this frequency will be given by the angular velocity denoted by ω. If we denote the natural frequency by ν the condition will be $\nu < \frac{\omega}{2}$. The natural frequency of a system consisting of the mass m and the resiliency c will be $\nu = \sqrt{\frac{c}{m}}$, where c stands for P/d, P denoting the force applied (the load), and d the deflection caused by this load. The value of this quotient can be derived from Hook's Law as follows:—$d = P\,l/E\,A$, where for the case in question l denotes the thickness of the cork, E the modulus of elasticity, and a the area of the cork. For the unit of area with $P/a = p$, $c = E/l$ and $\nu = \sqrt{E/l\,m}$. This equation enables the designer to assess the efficiency of the insulation for the different impressed frequencies that might occur. The motor, *e.g.*, revolving at 1450 r.p.m., corresponding to an angular velocity 151·5, would require a natural frequency of at least 75·75. With these values the thickness of cork required works out at 11·5in., which means that the foundations will not prevent the transmission of vibrations of the motor if 2in. pads are used. This is the reason why, even on cork-isolated foundations, the motors are isolated by spring isolators, because it is easy to obtain the resiliency required by a spring.

The equation shows us that for 2in. of cork the impressed frequency must reach a value of at least 3450 per minute, corresponding with an angular velocity of 362 radians per second. We can, furthermore, infer from the equation that for lower frequencies the thickness of cork will become prohibitive, and in such cases resort must be made to spring isolators, an element which meets all requirements with respect to resiliency without difficulty.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

SUPPLY OF TRAINED WELFARE WORKERS FOR INDUSTRY

SIR,—Recent utterances by the Minister of Labour have served to stimulate interest in industrial welfare work, and many firms are now considering the appointment of a welfare or personnel worker. Unfortunately, as our correspondence shows, many of those so appointed know little or nothing of the duties involved and are without any previous factory experience.

Some months ago the Ministry gave approval and financial support to suitable courses on the subject at the universities of Birmingham, Cambridge, Edinburgh and Liverpool, as well as practical training in the welfare departments of factories. As a result a number of qualified candidates, both men and women, are now available to take up posts in industry.

May I therefore suggest to employers and others who contemplate making appointments of such persons that they should first communicate either with the Factory and Welfare Department of the Ministry of Labour, Cleland House, Paige Street, S.W.1, or the Industrial Welfare Society, 14, Hobart Place, S.W.1? ROBERT R. HYDE.

Industrial Welfare Society,
London, April 16th.

NEW RUSSIAN STEEL WORKS.—Commissions have been set up in the U.S.S.R. to select sites for new steel works in Siberia and the Southern Urals, respectively. The Siberian plant, scheduled for completion in 1944–45, is to be based on local ores and Kuznetsk coal, and the other, also based on local resources, is due to be completed about the same time. The two works are intended to form the bases for the iron and steel industry in Siberia.

"RAIDSAFE" SHELTERS.—In our issue of December 13th, 1940, we described and illustrated the "Raidsafe" shelter made by Andamite, Ltd., of 52, Ebury Street, London, S.W.1. The firm now informs us that it was recently approached by the Ministry of Aircraft Production with a view to re-designing the shelter for use as a fire-watchers' post. The Ministry has since approved the resulting design. The firm has also brought out a canopy unit for the protection of vital plant. A special arrangement of bracing members reduces the floor space required to support the canopy. The canopy unit is adjustable for angle. It is made up of two H-section, 5in. by 3in., steel upright stanchions mounted on base plates and carrying a pivoted angle steel frame. The latter carries three ¾in. "Durasteel" composite steel and asbestos panels, giving a total area of cover of about 45 square feet. The canopy is strong and resilient enough to carry a considerable *débris* load and gives some protection from H.E. splinters and more complete protection from blast, *débris* and incendiary bombs.

Non-Dimensional Characteristic Design Factors for Turbo-Machines

By J. R. FINNIECOME, M.Eng., M.I. Mech. E., M. Soc. C.E.

FROM time to time attention has been directed in this and other journals to the principal non-dimensional characteristic factors relating to turbo-machines. These valuable contributions have emphasised the practical significance of the various clearly defined formulæ. It seems therefore desirable to study the wealth of information thus made available and then to examine the formulæ carefully in the light of present knowledge and practical experience. Hence it seems opportune to analyse the various expressions for the characteristic factors with a view to correlating them in a concise summary. The writer also regards it as desirable to introduce an entirely new series of formulæ based principally on the fundamental expressions recommended by the different authorities on the subject. In recent years there has been a general urge towards the scientific analysis of design and test data. It may therefore be noted that the proposed modified expressions are admirably suited for this purpose.

A critical examination of the general basic formulæ reveals that by introducing the ratio of the velocities and the dimensions* at the discharge of the runner and other essential factors influencing the performance, one can derive an interesting series of useful expressions which should prove valuable for correlating the design data of both radial and axial flow turbo-machines, such as turbo-blowers and compressors, superchargers, fans, and pumps. These modified formulæ also furnish a very simple basis for a comparative analysis of the data relating to similar types of turbo-machines.

The following notation is used :—

n=Speed in revolutions per second.
n_s=Specific speed number.
h=Head per stage.
ρ=Density.
q=Volume at discharge of runner.
P=Power supplied to runner=$g\,h\,q\,\rho/\eta_P$.
g=Gravitational acceleration.
d_2=Tip diameter of runner.
d_1=Root diameter of runner for axial flow.
b_2=Radial width of runner at tip.
u_2=Tip velocity of runner.
C_o=Theoretical velocity due to the head $=\sqrt{2\,g\,h}$.
C_m=Velocity of medium flowing through the annulus at discharge of runner.
η_p=Efficiency.
ψ=Head factor.

It should be noted that either the pound-foot-second, the kilogramme-metre-second, or any other system of units can be used for these quantities, and that n is, as a consequence, always expressed in revolutions per second.

* K. Baumann, "Some Recent Developments in Large Steam Turbine Practice," The Institution of Electrical Engineers, Vol. 59, No. 302, p. 602.

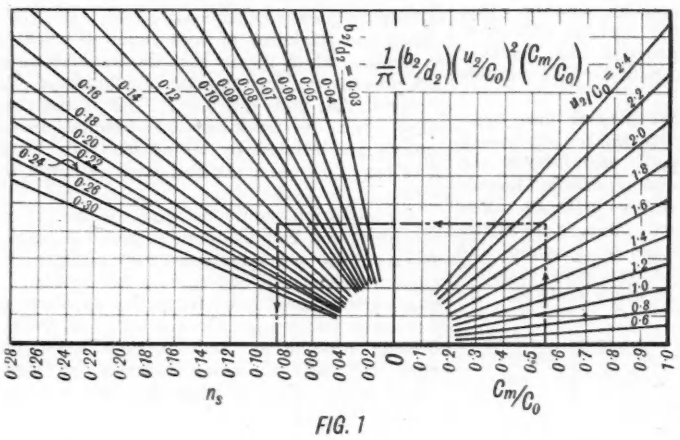


FIG. 1

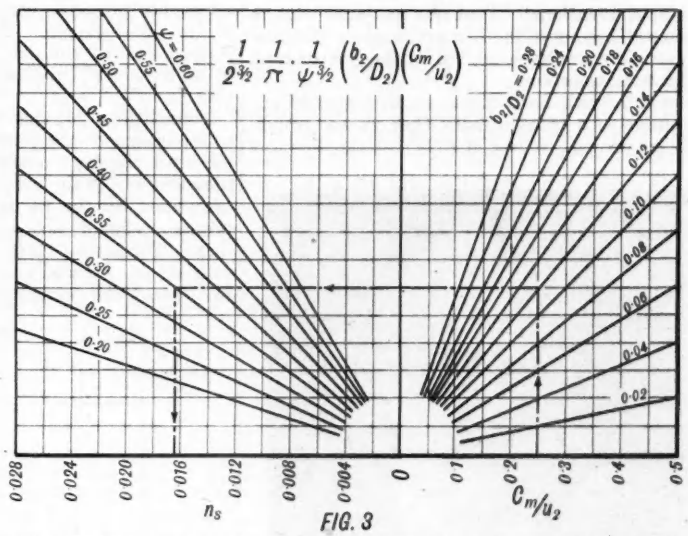


FIG. 3

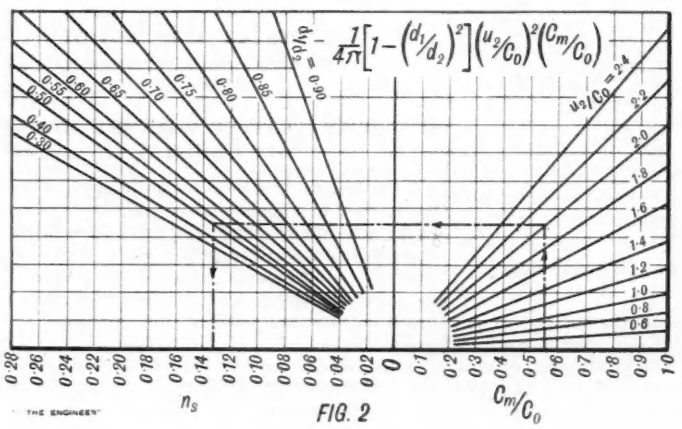


FIG. 2

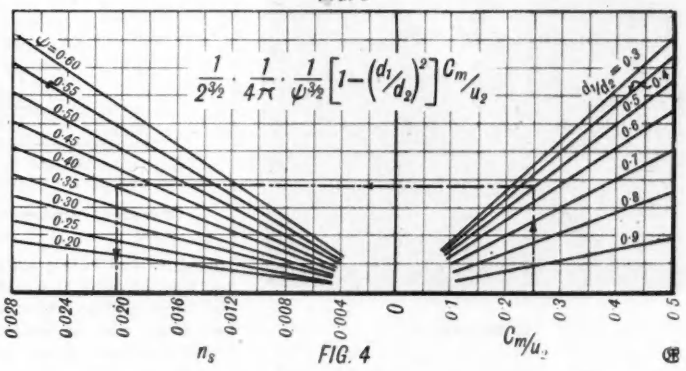


FIG. 4

TABLE I.—*Non-dimensional Characteristic Speed Numbers for Turbo-Machines.*
(Pumps, Compressors, Blowers, Fans.)

1	2	3	4	5	6	7
	General basic formulæ.		Modified expression. Radial flow.		Modified expression. Axial flow.	
1	$\frac{n\,P^{1/2}}{(\rho\,g\,h)^{1/2}\,(2\,g\,h)^{3/4}}$	1	$\frac{1}{\pi^{1/2}}\left(\frac{b_2}{d_2}\right)^{1/2}\left(\frac{u_2}{C_o}\right)\left(\frac{C_m}{C_o}\right)^{1/2}\frac{1}{\eta_p^{1/2}}$	1a	$\frac{1}{2\,\pi^{1/2}}\left[1-\left(\frac{d_1}{d_2}\right)^2\right]^{1/2}\left(\frac{u_2}{C_o}\right)\left(\frac{C_m}{C_o}\right)^{1/2}\frac{1}{\eta_p^{1/2}}$	1b
2	$\frac{n\,q^{1/2}}{(g\,h)^{3/4}}$	2	$\frac{2^{3/4}}{\pi^{1/2}}\left(\frac{b_2}{d_2}\right)^{1/2}\left(\frac{u_2}{C_o}\right)\left(\frac{C_m}{C_o}\right)^{1/2}$	2a	$\frac{1}{2^{1/4}\,\pi^{1/2}}\left[1-\left(\frac{d_1}{d_2}\right)^2\right]^{1/2}\left(\frac{u_2}{C_o}\right)\left(\frac{C_m}{C_o}\right)^{1/2}$	2b
3	$\left(\frac{q}{n\,d^3}\right)^{1/2}$	3	$\pi\left(\frac{b_2}{d_2}\right)^{1/2}\left(\frac{C_m}{u_2}\right)^{1/2}$	3a	$\frac{\pi}{2}\left[1-\left(\frac{d_1}{d_2}\right)^2\right]^{1/2}\left(\frac{C_m}{u_2}\right)^{1/2}$	3b
4	$\frac{n\,q}{g\,h\,d}$	4	$2\left(\frac{b_2}{d_2}\right)\left(\frac{u_2}{C_o}\right)\left(\frac{C_m}{C_o}\right)$	4a	$\frac{1}{2}\left[1-\left(\frac{d_1}{d_2}\right)^2\right]\left(\frac{u_2}{C_o}\right)\left(\frac{C_m}{C_o}\right)$	4b
5	$\frac{n^2\,q}{(g\,h)^{3/2}}$	5	$\frac{2^{3/2}}{\pi}\left(\frac{b_2}{d_2}\right)\left(\frac{u_2}{C_o}\right)^2\left(\frac{C_m}{C_o}\right)$	5a	$\frac{2^{3/2}}{4\,\pi}\left[1-\left(\frac{d_1}{d_2}\right)^2\right]\left(\frac{u_2}{C_o}\right)^2\left(\frac{C_m}{C_o}\right)$	5b
6	$\frac{n^2\,q}{(2\,g\,h)^{3/2}}$	6	$\frac{1}{\pi}\left(\frac{b_2}{d_2}\right)\left(\frac{u_2}{C_o}\right)^2\left(\frac{C_m}{C_o}\right)$	6a	$\frac{1}{4\,\pi}\left[1-\left(\frac{d_1}{d_2}\right)^2\right]\left(\frac{u_2}{C_o}\right)^2\left(\frac{C_m}{C_o}\right)$	6b

This general survey considers the non-dimensional expressions, first, for the characteristic speed number, and, secondly, for the head, volume, and power factors.

CHARACTERISTIC SPEED NUMBER

A summary of the general basic formulæ and the modified expressions, proposed by the writer, incorporating the ratio of the velocities and the dimensions at the discharge of the runner, are given in Table I. A similar series of formulæ, including also the head factor ψ defined as $g\,h/u_2^2$, is given in Table II. The general basic expressions are those recommended by (1) Spannhake, (2) by McDonald and Jennings, (3) by Jennings, (4) by McDonald, (6) by Dubs, Hanocq, and the writer. It will be observed that at least six closely related formulæ are used to express the characteristic speed number. It seems most desirable that designers should agree to a universal standard formula for the characteristic speed number. The writer advocates as a comparative standard for the characteristic speed number,

(*a*) The general basic formula

$$n_s = n^2 q/(2\,g\,h)^{3/2} \quad . \quad . \quad . \quad (6)$$

for it is readily expressible in the modified forms which give in simple terms the best relationship between the principal design factors.

(*b*) The modified expression derived from the above formula (6),

(1) Based on the ratio of the velocities and the dimensions :—

For radial flow

$$n_s = \frac{1}{\pi}\left(\frac{b_2}{d_2}\right)\left(\frac{u_2}{C_o}\right)^2\left(\frac{C_m}{C_o}\right) \quad . \quad . \quad . \quad . \quad (6a)$$

For axial flow

$$n_s = \frac{1}{4\,\pi}\left[1-\left(\frac{d_1}{d_2}\right)^2\right]\left(\frac{u_2}{C_o}\right)^2\left(\frac{C_m}{C_o}\right) \quad . \quad . \quad (6b)$$

(2) Based on the ratio of the velocities, and the dimensions and the value ψ :—

For radial flow

$$n_s = \frac{1}{2^{3/2}} \cdot \frac{1}{\pi} \cdot \frac{1}{\psi^{3/2}} \left(\frac{b_2}{d_2}\right)\left(\frac{C_m}{u_2}\right) \quad . \quad . \quad . \quad (6c)$$

For axial flow

$$n_s = \frac{1}{2^{3/2}} \cdot \frac{1}{4\pi} \cdot \frac{1}{\psi^{3/2}} \left[1 - \left(\frac{d_1}{d_2}\right)^2\right]\left(\frac{C_m}{u_2}\right) \quad . \quad (6d)$$

The expressions (6*a*),(6*b*),(6*c*), and (6*d*) are represented graphically—with a typical example shown for each case by dotted lines and arrows—in Figs. 1, 2, 3, and 4 respectively.

Head, Volume, and Power Factors

It is of particular interest to include in this résumé also the characteristic factors relating to the head, the volume, and the power of turbo-machines. A summary of the general basic formulæ proposed by Rateau nearly forty years ago, and the modified expressions introduced by the writer on the basis of the ratio of the velocities and the dimensions, and the value ψ is given in Table III, columns 3 and 5. In addition, the design factors are given in column 7, and conversion factors for the general basic formulæ in column 9.

The modified expressions in Tables I, II, and III illustrate in a simple manner the relationship between the various design factors. Their adoption should simplify the task of correlating the design particulars and test data. Furthermore, the tables present the relationship of the different expressions for the characteristic factors generally used in the design of turbo-machines.

It is hoped that not only those closely associated with the design of turbo-machines, but also others, will find this summary of the formulæ and the series of charts of interest and practical value. This summary should clear up many outstanding points of interest.

Table II.—*Non-dimensional Characteristic Speed Numbers for Turbo-Machines.*
(Pumps, Compressors, Blowers, Fans.)

1	2	3	4	5	6	7
	General basic formulæ.		Modified expressions. Radial flow.		Modified expressions. Axial flow.	
1	$\frac{n\,P^{1/2}}{(\rho\,g\,h)^{1/2}\,(2\,g\,h)^{3/4}}$	1	$\frac{1}{\pi^{1/2}} \cdot \frac{1}{(2\psi)^{3/4}} \cdot \left(\frac{b_2}{d_2}\right)^{1/2} \cdot \left(\frac{C_m}{u_2}\right)^{1/2} \cdot \frac{1}{\eta_p^{1/2}}$	1c	$\frac{1}{2\pi^{1/2}} \frac{1}{(2\psi)^{3/4}} \left[1-\left(\frac{d_1}{d_2}\right)^2\right]^{1/2} \left(\frac{C_m}{u_2}\right)^{1/2} \frac{1}{\eta_p^{1/2}}$	1d
2	$\frac{n\,q^{1/2}}{(g\,h)^{3/4}}$	2	$\frac{1}{\pi^{1/2}} \cdot \frac{1}{\psi^{3/4}} \cdot \left(\frac{b_2}{d_2}\right)^{1/2} \left(\frac{C_m}{u_2}\right)^{1/2}$	2c	$\frac{1}{2\,\pi^{1/2}} \cdot \frac{1}{\psi^{3/4}} \left[1-\left(\frac{d_1}{d_2}\right)^2\right]^{1/2} \left(\frac{C_m}{u_2}\right)^{1/2}$	2d
3	$\left(\frac{q}{n\,d^3}\right)^{1/2}$	3	$\pi \left(\frac{b_2}{d_2}\right)^{1/2} \left(\frac{C_m}{u_2}\right)^{1/2}$	3c	$\frac{\pi}{2} \left[1-\left(\frac{d_1}{d_2}\right)^2\right]^{1/2} \left(\frac{C_m}{u_2}\right)^{1/2}$	3d
4	$\frac{n\,q}{g\,h\,d}$	4	$\frac{1}{\psi} \left(\frac{b_2}{d_2}\right) \left(\frac{C_m}{u_2}\right)$	4c	$\frac{1}{4\,\psi} \left[1-\left(\frac{d_1}{d_2}\right)^2\right] \left(\frac{C_m}{u_2}\right)$	4d
5	$\frac{n^2\,q}{(g\,h)^{3/2}}$	5	$\frac{1}{\pi} \frac{1}{\psi^{3/2}} \left(\frac{b_2}{d_2}\right) \left(\frac{C_m}{u_2}\right)$	5c	$\frac{1}{4\,\pi} \cdot \frac{1}{\psi^{3/2}} \left[1-\left(\frac{d_1}{d_2}\right)^2\right] \left(\frac{C_m}{u_2}\right)$	5d
6	$\frac{n^2\,q}{(2\,g\,h)^{3/2}}$	6	$\frac{1}{2^{3/2}} \cdot \frac{1}{\pi} \cdot \frac{1}{\psi^{3/2}} \left(\frac{b_2}{d_2}\right) \left(\frac{C_m}{u_2}\right)$	6c	$\frac{1}{2^{3/2}} \cdot \frac{1}{4\,\pi} \cdot \frac{1}{\psi^{3/2}} \left[1-\left(\frac{d_1}{d_2}\right)^2\right] \left(\frac{C_m}{u_2}\right)$	6d

Table III.—*Non-dimensional Characteristic Factors for Turbo-Machines.*
(Pumps, Compressors, Blowers, Fans, &c.)

1	2	3	4	5	6	7	8	9
	Characteristic factor.	General basic formula.		Modified expressions. Corresponding to values of col. 3.		Modified expressions. Design factor.		Conversion factor, $\frac{\text{col. 3}}{\text{col. 7}} = \frac{\text{col. 5}}{\text{col. 7}}$
1	Head	$\frac{g\,h}{n^2 d^2}$	7	$\pi^2 \frac{h}{u^2_{2/g}} = \pi^2\psi$	7*a*	$\frac{h}{u^2_{2/g}} = \psi$	7*c*	π^2
2				$\frac{\pi^2}{2}\left(\frac{C_2}{u_2}\right)^2$	7*b*	$\left(\frac{C_2}{u_2}\right)^2$	7*d*	$\frac{\pi^2}{2}$
3	Volume	$\frac{q}{n\,d^3}$	8	$\pi^2 \left(\frac{b_2}{d_2}\right)\left(\frac{C_m}{u_2}\right)$	8*a*	$\left(\frac{b_2}{d_2}\right)\left(\frac{C_m}{u_2}\right)$	8*b*	π^2
4	Power	$\frac{g\,h\,q}{n^3 d^5 \eta_p}$	9	$\pi^4\psi \left(\frac{b_2}{d_2}\right)\left(\frac{C_m}{u_2}\right)\frac{1}{\eta_p}$	9*a*	$\psi\left(\frac{b_2}{d_2}\right)\left(\frac{C_m}{u_2}\right)\frac{1}{\eta_p}$	9*c*	π^4
5				$\frac{\pi^4}{2}\left(\frac{b_2}{d_2}\right)\left(\frac{C_2}{u_2}\right)^2\left(\frac{C_m}{u_2}\right)\frac{1}{\eta_p}$	9*b*	$\left(\frac{b_2}{d_2}\right)\left(\frac{C_2}{u_2}\right)^2\left(\frac{C_m}{u_2}\right)\frac{1}{\eta_p}$	9*d*	$\frac{\pi^4}{2}$

Mercury Problems.—The cheapening of the production of mercury from low-grade ores is engaging the attention of American experts. The average mercury content of United States ores is at present probably as low as 0·35 per cent., and although their exploitation is profitable under current prices for the Spanish-Italian metal, lower world prices for mercury have in the past invariably checked the use of an ore from the Mirabel mine in California, the gangue being largely serpentine and the head assay about 0·33 per cent. quicksilver, cinnabar being the only sulphide mineral present. Another ore investigated comes from the Yellow Pine district in Idaho, with an average head assay of 0·90 per cent. quicksilver.

The Use of Cast Iron in Building*

By S. B. HAMILTON

The period covering the use of cast iron in building is roughly the nineteenth century. It is not proposed, in this paper, to consider the use of cast iron in bridges, for two reasons: the subject is too large; and its history is better known than that of the early use of cast iron in buildings, with which, moreover, the author is more directly familiar. Except for Sir William Fairbairn's classic work "On the Application of Cast and Wrought Iron to Building Purposes" (1854), there is very little literature accessible on this latter subject. Like most new developments in technology of a century and a-half ago, the early examples of cast iron structures owed nothing to theory. They "just grew," but as the use of the new material widened it raised problems which mere empiricism could not solve; and about 1830 the tentative phase ended, and cast iron construction became a subject of deliberate experiment and scientific study. The culminating period came with the eighteen-fifties, after which gradual decline set in.

The Tentative Period of Cast Iron Construction

About the year 1800 the typical textile mill building consisted of a rectangular block with brick walls, timber plank floors, beams of square timber baulks which reached from one side of the building to the other. The span was divided by cast iron columns, with flat bases and caps. These stood on the beams at one floor and supported the beams of the floor above. The whole weight of the upper part of the building was carried from one tier of columns to the tier below through the timber beams. No attempt was made in such buildings to make metal-to-metal contact between the columns of successive stories. The rigidity of such mill buildings depended entirely upon the masonry or brickwork of the walls. The height to which they could be built was limited by the crushing strength of the timber across the grain. Heavy timber beams and thick planks possess a fairly high degree of fire resistance; but if a fire on a lower floor got out of control the whole structure was doomed. Hence, even though its construction was comparatively expensive, manufacturers began to regard a "fireproof" mill building well worth a considerable additional outlay of capital. According to Fairbairn, the first building of this kind was erected in 1801 by Messrs. Boulton, Watt and Co. for Messrs. Philips and Lee, cotton spinners, of Manchester. All timber was excluded from the structure, cast iron being introduced as the material for the beams. The beams spanned 14ft. between cast iron columns, and brick arches of 9ft. span were built from beam to beam to carry stone flag floors of which there were seven above ground floor, 10ft. apart. Strictly speaking, this construction was not "fireproof," as exposed ironwork will weaken and collapse if heated to redness; but the absence of combustible material in the structure greatly limited the risk of a local outbreak of fire spreading through the building.

Henry Maudslay (1771–1831) was a pioneer in the use of cast iron in machinery. He seems also, from a note in Richard Beamish's "Memoir of the Life of Sir Marc Isambard Brunel" (London, 1862), to have attempted its use in building. Maudslay opened a workshop in Lambeth Marsh in 1810, of which the buildings underwent numerous changes as his business extended. Brunel seems, according to Beamish, who served as his assistant in the cutting of the Thames Tunnel, to have had an almost instinctive sense of the adequacy or otherwise of structures. Passing Maudslay's works in 1826, Brunel noticed the erection of a curious cast iron roof which aroused his suspicions. It collapsed shortly afterwards.

Work on Cast Iron Beams by Hodgkinson and Fairbairn

The first definite contribution to knowledge of the behaviour under load of cast iron beams was due to the labours singly and jointly of Eaton Hodgkinson (1789–1861) and Sir William Fairbairn (1789–1874). Fairbairn was commissioned in 1824 to built fireproof mill buildings for Messrs. Gott, of Leeds, and a Mr. Wood, of Bradford. He was not satisfied that either the narrow T section used in 1800 by Boulton and Watt or the I section recommended by Thomas Tredgold (1788–1829) was the strongest obtainable with a given weight of metal. Tredgold had made some experiments several years earlier and reported the results in the second edition (1824) of his "Practical Essay on the Strength of Cast Iron," but had failed to disprove his erroneous assumption that cast iron was as strong to resist tension as it was to resist compression. For the Leeds building Fairbairn used beams of 14ft. and of 16ft. span. But for the Bradford building, after casting and testing a number of experimental beams, he boldly increased the span to 20ft. and made his beams of a section like the profile of a collar stud. 18in. deep at mid-span graded off to 11½in. deep at the bearing.

Hodgkinson's work on cast iron beams was reported in the form of papers submitted to the Literary and Philosophical Society of Manchester, and published in their "Memoirs" (second series):—(1) "On the Transverse Strength of Materials" (read 1822: "Mem.," Vol. IV); (2) "Theoretical and Experimental Researches to Ascertain the Strength and Best Form of Iron Beams" (read 1830: "Mem.," Vol. V.). Hodgkinson in the earlier paper added nothing of importance to the theory of bending. Like Coulomb, he realised that the fibre of beams of such materials as timber both stretched and compressed; but, also like Coulomb, he considered that beams of hard brittle materials were practically incompressible and behaved in accordance with Mariotte's hypothesis, which placed the neutral axis at or close to the surface of the compression side of the beam. Hodgkinson appears to have known Coulomb's work only through Professor Robison, to whom he attributed it as original.

Though cast iron possessed, at least under moderate loading, equal elasticity in tension and compression, it was far from being equally strong to resist tensile and compressive stresses. Hodgkinson demonstrated this effectively by testing T sections in bending with the table first on the convex then on the concave side, finding the relative strength of cast iron specimens in the two cases to be as 4 to 1, although no difference was found when similar wrought iron specimens were similarly tested.

To carry out experiments on a larger scale Hodgkinson needed more powerful testing plant and financial backing than he possessed. A Mr. Ewart, probably Peter Ewart (1767–1842), to whom Hodgkinson showed his earlier results, introduced him to Fairbairn and Lillie. Hodgkinson's later work was carried out in close collaboration with Sir William Fairbairn, who provided both the machinery and the specimens required to continue his investigations.

The section of a member subject to bending is divided by a "neutral axis," where the fibres are neither compressed nor stretched, into areas subjected to compressive and tensile stresses. If the material is not equally capable of resisting crushing and tearing, these areas should be unequal. In actual cast iron beams the ideal shape for maximum strength is not feasible, as it would require a thick, heavy tension flange connected by a thin web to a small compression flange. Such a casting would cool and set unequally, suffering in consequence from serious internal stresses. In sections which could safely be cast the ratios of the maximum compressive and tensile stresses were nearer three than the ideal ratio of six.

Sir William Fairbairn's Views on Cast Iron Construction

According to Fairbairn (*op. cit.*, p. 24), the relative strengths for equal weight of metal of the beams hitherto mentioned could be expressed as ratios to that of Hodgkinson's ideal section, in reversed chronological order thus:—

Hodgkinson (1830)	1·00
Fairbairn (1825)	0·75
Tredgold (I section) (1824)	0·62
Boulton, Watt and Co. (1801)	0·54

Fairbairn stated that bridge girders up to 40ft. span in a single casting might be constructed with safety

* Newcomen Society, April 23rd. Greatly abridged.

if proper precautions were taken in the moulding; that beams of 76ft. span had on one occasion been made in single castings in this country and shipped to Amsterdam for use on the Haarlem Railway. When either design or construction was undertaken by ignorant persons, however, there was serious risk of accident involving loss of life and extensive damage to property. Fairbairn was called in to diagnose several such failures in the course of his career.

A cotton mill in Oldham collapsed completely in October, 1844, killing twenty people (Fairbairn, *op. cit.*, Appendix II, p. 274). The building was carried on cast iron columns supporting beams of just under 14ft. span, spaced from 10ft. 2in. to 11ft. 3in. apart. At the gable end of the mill secondary beams spanning 15ft. 3½in. brought concentrated loads to bear on the last row of main beams, which differed from the other main beams only by being cast with stronger webs. The bottom flanges were the same in all the main beams, and beams in the last row, which carried the secondary beams, were stressed according to Fairbairn's calculation, to 90 per cent. of their normal breaking load. The rise of the arches between the main beams was 12in., which Fairbairn considered too little. Not less than 1½in. per foot of span should be allowed. The tie rods also were placed on top of the beams, 18in. from the bottom flange. Tie rods should never, he contended, be higher than the soffits of the arches. The columns also were too slender and of varying thickness owing to bad coring.

Several days before the disaster one of the return arches sank 4in. Immediate preparations were made to fix temporary centres, and the middle third strip of the fallen arch was rebuilt. It was not stated whether the adjacent ironwork was examined for cracks, at the time the arch was repaired; but as soon as the arch resumed its proper thrust a beam broke off short by the column and fell. Complete collapse of the building ensued. Doubtless the columns broke in rapid succession, as they were already weak, and would be quite incapable of resisting the bending forces to which they would be subjected once the balance of the floor arches was disturbed.

Another failure was described by Fairbairn before the Institution of Civil Engineers on April 20th, 1847 ("Proc.," Inst. C.E., 1847):—Gray's cotton mill in Manchester possessed a flat roof used as a tank and carried on cast iron girders of 32ft. span. The girders, which were in their original state of reasonably correct proportions for normal floor loads, were strengthened by trussing to carry the tank. This relieved the tension flange, but left the girders weak in compression. Fairbairn reckoned that the load borne by the girder was 94 per cent. of the calculated breaking load. One beam failed in compression; the rest followed. Fairbairn recorded and illustrated some actual details of beams and their connections according to the best practice of his day. The tie bars provided to relieve the beams from the thrust of the floor arches were members of great importance. Sometimes, as in Benyon's mill in Leeds, these were screwed at the end; sometimes the bars were forged to a gib end, two from adjacent spans passing through the same hole, where they were retained by a cotter. Another method was to use iron rings, passing them over half-bosses cast at the sides of the beam ends where these embraced the column, as in fly-wheel construction.

Hodgkinson recommended the casting of beams with parallel flanges of constant thickness, but varying width, parabolic in plan, as saving 30 per cent. of the metal which was required when the section necessary at mid-span was carried through the whole length of the beam. When the foot of one column stood upon the head of another, Fairbairn considered the meeting faces should be machined.

The customary size of columns in mill buildings was 6½in. to 7in. diameter, to carry beams up to 18ft. span, 8in. diameter to carry beams up to 25ft. span, the thickness of metal being reduced from 1⅛in. in the lower part of the building to ⅝in. in the upper stories. These dimensions were empirical. No adequate theory of columns was yet in existence.

1830–1850: The Experimental Period

The period from 1830 to 1850 may be considered as that when cast iron was the most important material used by structural engineers. It was not yet seriously challenged by wrought iron, and it was adaptable to use in "fireproof" buildings where wood was undesirable. Its strength and properties were known and the variety of form in which it could be cast encouraged its use for ornamental purposes. An instance of this which occurs in "James Nasmyth, Engineer: An Autobiography" (edited by Samuel Smiles, LL.D., 1883, p. 183). Speaking of the year 1834, Nasmyth wrote: "Among the other well-known men to whom I was introduced at Liverpool was John Cragg, a most intelligent and enterprising iron-founder. He was an extensive manufacturer of the large sugar boiling pans used in the West Indies. He had also given his attention to the introduction of iron into buildings of different sorts. Being a man of artistic taste, he had even introduced cast iron into Gothic architecture. In order to exhibit, in an impressive form, the uses of his favourite metal, he erected at his own cost a very elegant church in the northern part of Liverpool. Cast iron was introduced, not only in the material parts of the structure, but in the Gothic columns and Gothic tracery of the windows, as well as into the lofty and elegant spire. Iron was also employed in the external ornamental details where delicate yet effective decoration was desirable. The famous architect Edward Blore was the designer of the church, and the whole details of the building, of which cast iron formed the principal material, were executed to his entire satisfaction."

The Culminating Period

The columns and arches of Paddington Station (1849–54) provide a good example of the use of cast iron in a new type of structure, perhaps happier than attempts to imitate Gothic details in a material of which the properties were far removed from those of stone. The elaborately decorated castings of the Coal Exchange in Fenchurch Street, London, are also worthy of note as an example of the taste of 1849.

The culminating period of cast iron construction must be considered to have arrived with the building of the Crystal Palace (1850). This amazing structure housed the Great Exhibition in Hyde Park in 1851 and afterwards formed for many years a landmark dominating South London from the heights of Penge until its destruction by fire on November 30th, 1936. The credit for that great work must be distributed between the Royal Society of Arts, which first decided to promote the exhibition; H.R.H. Prince Albert, who, as President of the Society, threw into the project his great energy and influence; Mr. Joseph Paxton, who suggested the form of a giant greenhouse, and fought down all opposition to his scheme; and—by no means least—Messrs. Fox, Henderson and Co., of Birmingham, who placed all their resources—financial, technical and administrative—at the disposal of the Commissioners to organise on a vast scale the design, manufacture and assembly of thousands of interchangeable parts. The cast iron alone incorporated in the building amounted to 3500 tons. Castings from the firm's own foundry in Smethwick, and from two others in Dudley, were machined to fit together at the site. All girders as they were unloaded from the wagons were weighed, clamped in a frame with ends which corresponded with the girder connections, loaded at two panel points by hydraulic jacks to their proof load, released and stacked all in four minutes. The wooden gutters, which, when trussed formed the gutter beams, were of a pattern devised by Paxton, cut in a moulding machine arranged by Mr. Couper, of Messrs. Fox, Henderson and Co., which cut out 2000ft. per day. The details of construction were fully described and illustrated in Vol. I of the Official Catalogue in THE ENGINEER for December 18th, 1936; and in "The Crystal Palace," by Peter Berlyn and Charles Fowler, jun. (London, 1851).

The Crystal Palace, although essentially a utilitarian structure, achieved no small degree of grace and beauty through sheer clean design and honesty of purpose. Its appearance was enhanced, in its second home, by the cast iron water towers, designed by Isambard Kingdom Brunel and erected between 1853 and 1856. These, though undamaged by the fire, are now being dismantled for the sake of the metal they contain.

The Decline of Cast Iron

Having traced the growth of cast iron construction from its tentative use by millwrights to the framework of important public and commercial buildings, it remains to explain briefly the causes of its ultimate decline.

Following Henry Fielder's patent of 1847 for building up beam sections by riveting angle iron flanges on to plate webs, the compound wrought iron beam gradually superseded the cast iron beam for large spans. Wrought iron could not, however, be produced in large sections and the fabrication of these from plates and angles was expensive. It was the introduction of mild structural steel in large billets, from which sections of many forms and of heavy weight could be rolled, which eventually rendered cast iron obsolete as a structural material. It remained until the end of the century the common material for columns for which it possessed several advantages; its compressive strength was high; it could be moulded into ornamental shapes and required no covering but paint. The typical city warehouse erected during the Victorian expansion of industry and commerce was a shell of heavy brickwork with wooden floors, timber beams, often flitched with iron plates, and cast iron columns. The vulnerability of such buildings to fire has been only too clearly shown within the last year; and, as old premises are demolished or rebuilt to meet new needs, the number of examples of cast iron construction still standing grows ever smaller.

It is interesting to note that attempts have been made since the outbreak of war to reintroduce cast iron into building to spread work more evenly between foundries and rolling mills, but the excessive drain which the heavy sections required would make on the raw material of steel has condemned these efforts to failure. The day of cast iron is over, but while it lasted the material gave to engineers an opportunity to develop methods of construction and a theory of structures which greatly eased their task when they came to apply wrought iron and structural steel. The ingenuity and courage of the nineteenth century pioneers was not wasted; we are benefiting to-day from their efforts, and while examples of their buildings still remain the least tribute we can pay to their memory is a record of their work, and an appreciation of their achievements.

The British Standards Institution in Wartime

SOME months before the outbreak of war the British Standards Institution offered the Government the services of the Institution, as a complete unit, in the national emergency. This offer, which was sent to the Board of Trade through which the B.S.I. receives its Government grant, was cordially received and the various Departments of State were duly informed of the proposal. On the outbreak of war the B.S.I. realised that its peacetime procedure was inadequate to deal effectively with the demands imposed by the changed conditions, and especially by the need for rapid action. A number of small executive committees were therefore set up for the various sections of its work, these being made fully responsible for the preparation of any war emergency specifications the Institution might be called upon to undertake. Under this emergency procedure the executive committees were given authority to restrict the usual wide consultation of industry to those interests directly concerned, and the reduction of the time usually given for comment on draft standards. Any British Standards issued under wartime procedure will, of course, come under review directly peace returns.

Government Departments are employing the B.S.I. machinery for the preparation, co-ordination, and promulgation of War Emergency Specifications to meet their several requirements. The Institution is invited to send a representative to appropriate meetings of the Materials Committee of the Production Executive, which is representative of all Government Departments, the Central Priority Department acting as the *liaison* between that Committee and the Institution. This arrangement has brought the B.S.I. into close contact with the increasing number of Departments working to specifications, and is thereby bringing about a considerable measure of co-ordination in their preparation and issue.

As an indication of the value of the work of the B.S.I. it may be mentioned that the first issue of the War Emergency Specifications for Tins and Cans for food products and other commodities is estimated to have saved 40,000 tons of steel in the first year. The work is being extended to cover packaging generally and has already involved the formation of more than eighty committees. A further example of the employment of the B.S.I. by the Ministry of Supply in effecting saving of material is the issue of a War Emergency Specification for Bolts and Nuts with smaller heads, which, it is estimated, will save many thousands of tons of steel a year.

Another example of the work of the Institution is the rationalisation of alloy and special steels. A committee under the chairmanship of Dr. W. H. Hatfield, F.R.S., has for some time past been engaged on an investigation of this complex matter and has drawn up a confidential report which includes suggestions for a co-ordinated series of steels. Such sections of the report as can be made available to the engineering public will shortly be issued by the Institution, which will at the same time issue War Emergency British Standards covering the steels recommended in the report. As a result of a conference held with the Director of Standardisation, the new Ministry of Works and Buildings is using the B.S.I. as the medium for the promulgation, under its authority, of a series of War Emergency British Standards for use at the present time. Similar action will probably be taken in respect of reconstruction work. At the request of the Ministry of Home Security a special series of specifications—about fifty in number at present—has been issued covering many aspects of A.R.P. work.

In connection with exemption from the Purchase Tax the B.S.I. has provided H.M. Government with definitions which give the dividing line between babies', children's, and adults' clothing, and made recommendations for protective boots designed for use by miners, quarrymen, or moulders. Recommendations have also been made in connection with the Limitation of Supplies Order. The experience of the B.S.I. is also being drawn upon in several directions through the Central Priority Department, where the preparation and issue of British Standards may not necessarily follow. In addition, in response to direct requests from industry, the Institution has prepared and issued a number of War Emergency Specifications to meet the special conditions resulting from the restriction in the supply of materials, and the demands for new and revised standards to meet these contingencies are increasing.

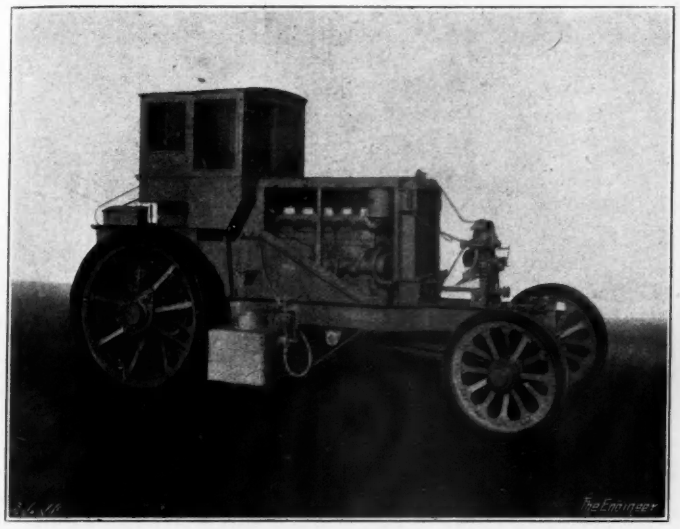
This war work has in no way prevented the B.S.I. from maintaining its usual close relationship with the Dominions' standardising bodies, which have been kept in close touch with these developments.

The B.S.I. Committee in the Argentine Republic, which is working in close collaboration with the I.R.A.M., the Argentine national standards organisation, is receiving increased recognition as its work is seen to be of real value to British export trade. British engineers and traders in the Argentine are to a greater degree giving practical support to the work of the Committee, and manufacturers in Great Britain have, by a far-sighted policy of financial support, made that work possible.

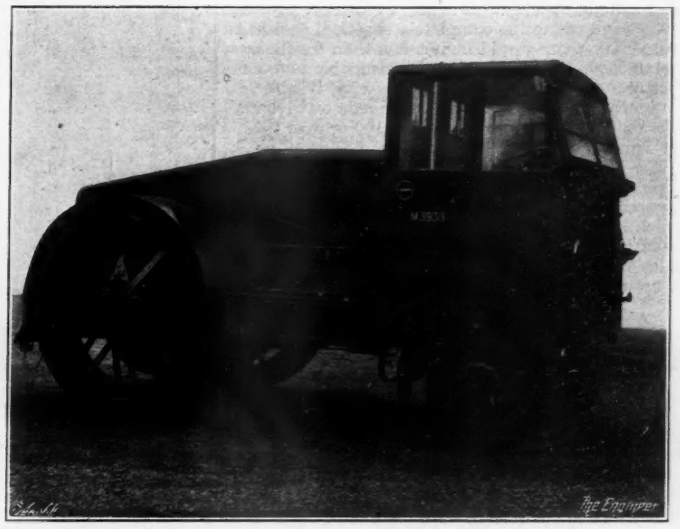
Oil Engine-Driven Traction Engine

IN the accompanying engravings we illustrate an entirely new design of oil engine-driven traction engine, which has been recently developed by J. and H. McLaren, Ltd., of Midland Engine Works, Leeds, for the use of contractors who specialise in the transportation by road of heavy indivisible loads, such as cannot be easily handled by rail. The traction engine shown in the drawings was built for the service of Pickfords, Ltd., and before delivery it underwent very successful trials.

The design adopted has been developed from an experimental engine shown in our first engraving, which has been under test for four years. Comparing the earlier with the later design, it will be clearly seen that while the experimental unit was in many respects a converted steam traction engine, the new design embodies in its forward section the best principles of modern lorry construction, while the rear end has a lay-out closely corresponding to that of the steam traction engine, with well-sprung solid-tyred driving wheels of large diameter.



EXPERIMENTAL TRACTION ENGINE



NEW 110 B.H.P. OIL ENGINE-DRIVEN TRACTION ENGINE

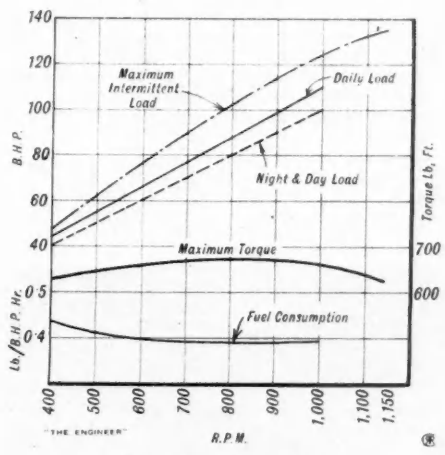
The principal dimensions and particulars of the traction engine are as follows:—

Dimensions and Particulars

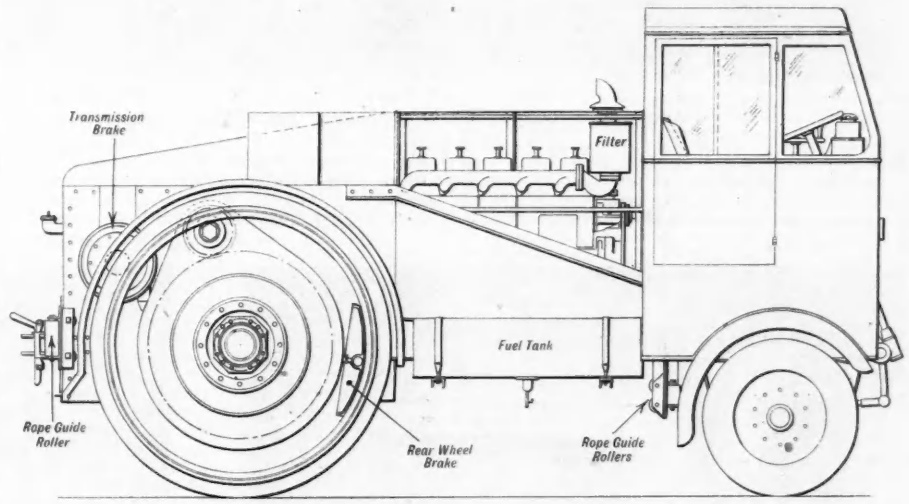
Wheel base	11ft.
Diameter of front wheels	36in.
Width of front wheels	8in.
Type of tyre	Pneumatic
Diameter of rear wheels	6ft.
Width of rear wheels	16in.
Type of tyre	Endless solid twin rubber
Overall length	17ft. 11in.
Overall width	8ft. 5in.
Overall height	9ft. 9in.
Minimum ground clearance	1ft.
Type of engine	McLaren-Ricardo 5-cyl.
Designed normal output	110 B.H.P.
Maximum intermittent output	125 B.H.P.
Speed	1000 r.p.m.
Bore	142 mm.
Stroke	200 mm.
Fuel consumption	Below 0·40 lb. per B.H.P./hr.

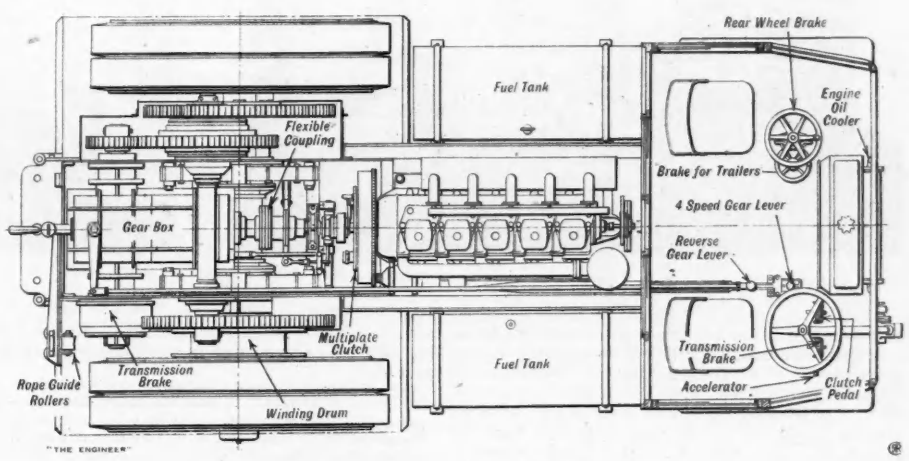
The performance of the engine is shown by the curves reproduced herewith. The accompanying drawing clearly shows the drive. Behind the engine is a multi-plate clutch built within the engine fly-wheel and provided with a stop to facilitate gear changes, which drive the rear wheels. The whole of the transmission mechanism is carried in ball and roller bearings. The main frame, which is supported by the rear driving wheels through short elliptical springs, is built up of steel channels and girder plates, which are rigidly stayed and are furnished with both front and rear draw-bars and rope guide rollers for the winding rope. The winding drum is mounted on the rear wheel axle and carries 50 yards of ⅞in. diameter steel rope, also a double-purchase snatch block. On the rear wheels strong brakes are fitted.

On each side of the chassis there are fuel tanks, having a total capacity of 125 gallons, sufficient for a journey of well over 100 miles, with loads up to 100 tons, without having to refuel. The roomy driving cab is of the coachbuilt pattern, with seats for the driver and assistant. It is furnished with an instrument panel carrying the oil gauges and ammeters, &c. On the driving side there is the steering wheel with the four-speed gear change lever and reversing lever, the clutch pedal, transmission brake pedal, and accelerator pedal. On the other side there are two hand wheels, one for the rear wheel brakes and the other for the transmission brake for trailers. The engine oil cooler is arranged in front of the radiator and consists of a transversely arranged section. The front axle steering gear is of the Ackerman type with the ordinary arrangement of steerage box, connecting-rods and levers. In designing the traction engine special care was taken with the distribution of weight in order to meet different classes of road met with in the service undertaken. The unladen weights are 3 tons 4 cwt. on the front wheels and 9 tons 11 cwt. on the rear wheels. These weights are increased to



ENGINE PERFORMANCE





ARRANGEMENT OF TRACTION ENGINE

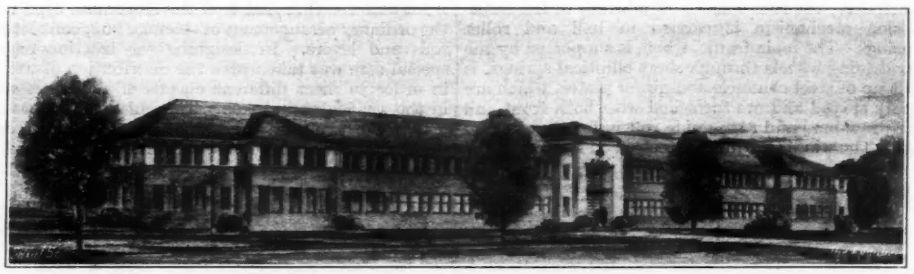
3 tons 7 cwt. and 10 tons 1 cwt. with the traction engine in working order, and to 3 tons 18 cwt. and 13 tons with the addition of removable ballast weights. In all three conditions steering is very easy. Assuming an overall efficiency of 85 per cent., the tractive efforts are 3090 lb. at 9·2 m.p.h., 5570 lb. at 5·43 m.p.h., 9620 lb. at 3·15 m.p.h., and 17,200 lb. at 1·76 m.p.h., the gear ratios being 22·1, 39·9, 69·1, and 123·4 to 1. The pull on the winding rope with the double-purchase snatch block is 40,800 lb.

Before delivery the traction engine we have described hauled a test load of 87 gross tons from the York district to Bradford, and since acceptance it has hauled a gross load of 109 tons from Birmingham to a South London district. During that journey 158 gallons of fuel were taken into the tanks, and that supply was sufficient for the whole journey, which was made *viâ* the firm's London depôt, making a total distance of 127 miles. Unfortunately, on completion of the trip the amount of fuel remaining in the tank was not checked. It is safe to assume, however, as the tank cannot be completely emptied, that in all probability there would be not less than 8 gallons of fuel unused. On that basis it is reasonable to assume that the 125-gallon fuel tank capacity is sufficient for journeys of 100 miles or more made on give-and-take roads and with gross loads of 100 or over behind the engine.

The haulage capacity of the new design of oil engine-driven traction engine has proved to be greatly in excess of that of the heavier steam traction engines, which are sometimes used for the haulage of similar loads in road transport service. The new engine is quiet in operation and is capable of a consistent speed of between 6 and 8 m.p.h. even with heavy loads.

Aeronautical Research in Australia

THE newly erected Australian Aeronautical Research Laboratory, illustrated on this page, forms part of the scheme for furthering aeronautical investigations adopted by the Australian Government on the advice of Mr. H. E. Wimperis, C.B., whose assistance they had invited on his relinquishment of the position of Director of Scientific Research at the British Air Ministry. The central building, now in part completed, will include ultimately a wing on the eastern side which will probably be devoted to chemical investigations. The site, formerly a golf links, passes now to the study of other forms of flight.

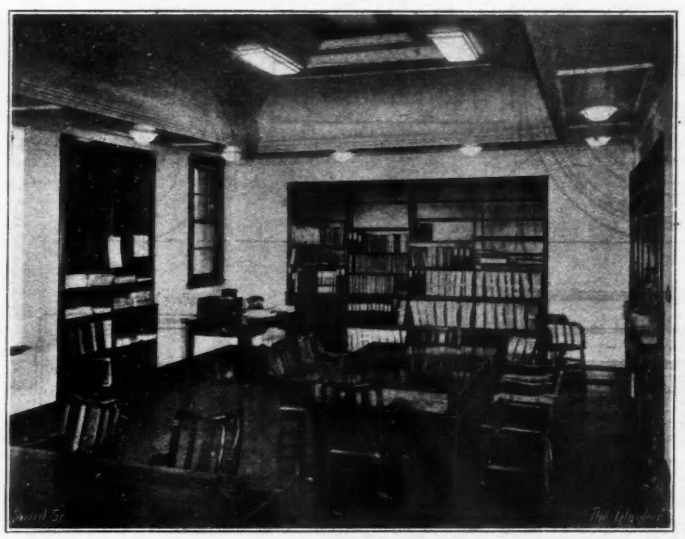


ARCHITECT'S CONCEPTION OF COMPLETE BUILDING

By the establishment of this laboratory and by creating a Chair of Aeronautics at Sydney University, now held by Professor A. V. Stephens, Fellow of St. John's College, Cambridge, the Australian Government has made scientific assistance available for the fast expanding aeronautical industry in that Dominion.

Besides the central building, which contains the administration, the conference room, the library and various testing laboratories, there will be a number of separate annexes to house a return circuit wind tunnel, a large engine testing plant, a small single-cylinder unit and other such equipment. Aerodrome facilities are available on the spot. The whole will represent a combination of the kind of experimental facilities available in this country at Teddington and Farnborough, though on a smaller scale. As in the United States and Canada, though not in this country, the administration comes under a Civilian Department of State and not under the Ministry of Defence, but means are available for keeping in close touch with the defence officers.

ADMINISTRATIVE BUILDING



LIBRARY

ENTRANCE HALL

The Administration is in the experienced hands of the Australian Council for Scientific and Industrial Research, of which Sir George Julius is Chairman and Sir David Rivett, K.C.M.G., the Chief Executive Officer. The recently appointed Head of the Division of Aeronautics is Mr. L. P. Coombes, D.F.C., lately a Principal Scientific Officer at the Royal Aircraft Establishment in this country.

MANGANESE IN MANCHURIA.—The Manchuria Mining Development Company has reported the discovery of manganese deposits at Hsihsien, Chinchow Province.

Cost of Rearmament*

WHEN President Roosevelt estimated in his Budget Message to Congress last month that the expenditures of the Federal Government during the fiscal year 1941–42 will reach a total of more than 17 billion† dollars, his words fell upon the ears of a people hardened by custom to the acceptance of billions as a commonplace of Government finance. Yet the President was dealing with a magnitude of which the human mind can form no clear conception. It is only by concrete examples that some idea of the vastness of such a sum can be gained.

Seventeen billion dollars would pay for the building of 335 battleships of the type of "Missouri" and "Wisconsin," now under construction at a cost of 50,700,000 dollars each, equivalent to more than twenty-two times the present United States battleship fleet and more than eight times the number of battleships now in service in the major navies of the world, exclusive of our own. Similarly, the money would pay for the construction of 423 aircraft carriers, such as the "Essex," "Bon Homme Richard," and "Intrepid," at 40,170,700 dollars apiece, or 782 heavy cruisers like the four now under construction at 21,746,600 each, or 976 light cruisers similar to the thirteen now being built at an average cost of 17,423,000 dollars, or 2684 2100-ton destroyers at 6,334,000 dollars, or 3333 1700-ton destroyers at 5,100,000 dollars, or 5862 submarines at 2,900,000 dollars each.

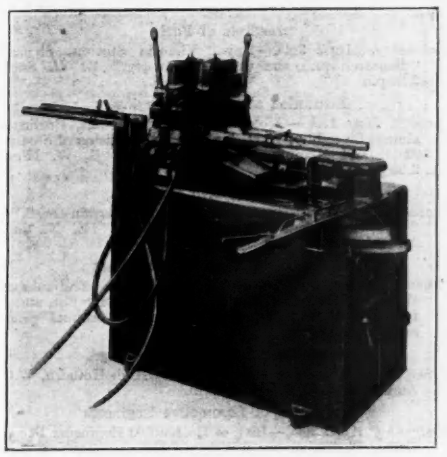
Seventeen billion dollars means an average of 129·11 dollars for every man, woman and child in the United States, or more than 500 dollars for each family of four. The 1941 Budget figure compares with total appropriations of the Federal Government of 463,383,480 dollars for 1891, 705,653,298 dollars for 1901, 1,039,550,617 dollars for 1911, 4,780,829,510 dollars for 1921, and 5,071,711,694 dollars for 1931. Before 1918 no annual figure had ever passed the two-billion-dollar mark.

* Guaranty Trust Company of New York.
† American billion = 1,000,000,000.

The annual interest on seventeen billion dollars at 2½ per cent. amounts to 425,000,000 dollars, or what it cost to run the entire Government fifty years ago. To earn this interest, the 48,400,000 employed workers of the country, as estimated for December by the National Industrial Conference Board, would have to work nearly two days each year at 5 dollars a day; and to pay the principal each one would have to work seventy days at the same rate.

Flash Butt Welder

An accompanying engraving illustrates a flash butt welder for medium and heavy duty made by the Arc Manufacturing Company, Ltd., of Goldhawk Road, W.12. This machine is claimed to incorporate many features not usually to be found in these units. It has been designed for a very wide application and, among other special features, removable stop bars are incorporated. This arrangement ensures rigidity for tool or short forging work, the welding heads acting as contact blocks only, thus saving the heavy wear caused by heavy mechanical pressure on such materials as copper and its alloys. The lever clamps are individually adjustable on a vertical spindle, thus allowing unequal sections to be handled in the welding heads, interchangeable blocks being fitted, and by a small movement the clamp can be closed. The machine illustrated has been specially fitted for



FLASH BUTT WELDER

tool production, having a circuit trip device, controlled from the operating lever of the machine. This lever carries an excentric toggle device, operating the upset ram, to which the upset or moving saddle is linked by means of a heavy square thread spindle. Rotation of this spindle determines the width of gap between the welding heads, and is locked against variation by means of the nut provided. To secure stability and consistency in operation a quadrant support is fitted so that no undue pressure is lost by the flexing of the operating lever, and it affords a mounting for a precise action circuit trip device. A second quadrant is fitted, having radial adjustment on its own axis, and by moving this quadrant to a predetermined position identical welds can be assured. A roller, bearing on the quadrant, is mounted on the operating handle of the trip switch fitted to the main lever. The switch is closed by clasping the thumb lever and handle together, and is kept closed throughout the entire operation. The switch, being spring loaded against the actuating lever, is immediately released and circuit broken as the roller slips its engagement on the quadrant by the movement of the operating lever, and the operator is relieved of the necessity of timing the "break." The machine illustrated is of 150 kVA capacity, welding up to 2in. diameter in alloy steel, at the rate of forty welds per hour, with a current consumption of approximately 1·3 units per weld. It will be appreciated that welding heads of this type are universal in use, in so far as rings or forgings of wide variation can be handled easily. As an alternative to hand lever pressure device, worm and worm wheel, with rack and pinion traverse mechanism, can be supplied, operated by capstan hand wheel. Many alternative designs of welding heads and clamps are available to meet the needs of a wide range of work.

TIN-PLATES BY A NEW PROCESS.—The Standard Steel Spring Company, of Coraopolis, Pa., has developed a method of producing tin-plate by electrolytic deposition first of nickel and then of tin on steel black plates and at the same cost as by the all-tin coating. Tests have shown that use of the electro-plated nickel-tin material for the manufacture of tin cans is quite satisfactory, providing adequate resistance to corrosion. The new method would use less than one-tenth the amount of tin used in the hot-dip process. The commercial applications of this form of tin-plate have so far been limited, but results from tests have proved satisfactory.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Official Announcements

The Board of Trade has issued the following announcements:—Under the Machinery, Plant and Appliances (Control) (No. 2) Order, 1941 (S.R. and O., 1941, No. 516), which comes into force on April 17th, 1941, the Machinery and Plant (Control) Order, 1940 (S.R. and O., 1940, No. 875) is so amended as to permit the supply without licence of machinery, plant and appliances by "manufacturers" (who include reconditioners), provided that they carry out no act of "manufacture" thereon and that they have not acquired it from another "manufacturer." The Schedules of the Machinery, Plant and Appliances to which the Orders relate are included in the Machinery and Plant (Control) (No. 2) Order, 1940, (S.R. and O., 1940, No. 1363), and the Machinery, Plant and Appliances (Control) Order, 1940 (S.R. and O., 1940, No. 2179). Copies of all the relevant Orders are obtainable from the Stationery Office, price 1d. Explanatory notices of earlier Orders appear in the *Board of Trade Journal* of August 1st, 1940, page 75, and January 2nd, 1941, page 2. Application forms for licences to acquire such machinery, plant and appliances may be obtained from the Industrial Supplies Department (Machinery Licences Division), Board of Trade, 1–6, Tavistock Square, London, W.C.1.

Under a Board of Trade Order which comes into force on April 30th, 1941, goods classified "C" in the Export Control List will require licences for export to China, Macao, Portuguese Timor and Thailand. The Order (S.R. and O., 1941, No. 523) also prohibits the export without licence to all destinations of certain textile machinery and plant. Copies of the Order will be available at H.M. Stationery Office on April 19th, 1941.

The Pig Iron Market

The consuming works are taking all the pig iron they can obtain, and the industry is pressing production to the limit in order to maintain full deliveries for the war industries. Consumers who are engaged upon non-essential work frequently have to wait a considerable time to obtain the pig iron they require and the distribution has been tightened up considerably in order to direct the production into channels associated with the national effort. On the North-East Coast the producers have to expend almost their whole effort in producing steel-making descriptions, and whilst now and again a furnace is put on to the production of foundry sorts, it is only occasionally and consumers are receiving their requirements from the Midland manufacturers. The steel works' needs are, of course, extremely heavy and are given precedence, but the home output, plus imported pig iron, is sufficient to meet the demand. Business in foundry iron has been maintained, but recently the expansion which had been going on for a few weeks does not appear to have made much headway. It is understood, however, that arrangements will shortly come into force by which the light castings manufacturers will be given a greater share in war work. They have been for some time seeking contracts of this character, and it is reported that increased efforts will be made to employ them to a greater extent on work of national importance. For a time complaints were frequent of the delay in deliveries, due principally to transport difficulties, but these appear to have been overcome, and consumers are now obtaining their pig iron supplies with much greater regularity. The demand for low-phosphoric iron is rather in excess of supplies and consumers are asked, wherever possible, to use high-phosphoric iron in order to relieve the pressure. Low-phosphoric and hematite kinds are used in large quantities by the heavy engineering industry, and there seems little likelihood of the demand from this direction slackening.

Scotland and the North

Production at the Scottish steel works is being held at high levels and the pressure of the demand upon all departments of the trade is fully maintained, so that the whole of the output passes rapidly into use. Practically the entire production is absorbed by consumers engaged upon war work. The general impression is that the needs of the war industries are being adequately met and that there is little to complain about in the matter of deliveries. Firms who are employed upon orders which do not come within the war categories, however, are finding it difficult to obtain supplies. All the heavy steel works have sufficient orders on their books to keep them busy for months. The demand from the shipyards is upon an increasing scale and the speeding up in ship construction has called for still larger supplies of steel. There is still some tightness in the plate position, but large supplies of imported material are being used and there is little delay arising from late deliveries. The tank and boilermakers are likely to be fully occupied for a long time and are taking up large tonnages of plates wherever possible. The constructional engineering firms, however, are not so busy as they were earlier in the year and there is still a noticeable quietness in the demand for heavy joists and sections. This industry is now assisting the shipbuilders by fabricating material for the yards and most of the firms engaged in the work are particularly busy. In the Lancashire district there is a noticeably strong demand for heavy plates, and bars, both light and heavy, are being taken up in large tonnages. Heavy joists and sections, however, are not required in the same quantity as a month or two ago. All classes of semi finished steel find an active demand. On the North-West Coast the steel rolling mills are fully employed and large tonnages of sections and hoops are being produced.

The Midlands and South Wales

The position in the semi-finished steel department is as satisfactory as can be expected under war conditions. The home output of steel ingots is understood to be rising, but the production of billets and sheet bars is required principally by the finishing mills associated with the producing works and the re-rolling industry is being supplied largely with imported material. This is available in sufficient quantities to enable consumers to work at capacity in most instances. The re-rolling works are receiving ample supplies and the production of small sections and bars is well maintained, but the output is passing into consumption directly it becomes available. The heavy steel works are fully employed and have a large volume of orders in hand. The plate position continues tight, and there is a heavy demand for nearly all thicknesses. Considering the extent of the demand, the time required for delivery in most cases is not unreasonable, particularly when the orders are for high priority work. Consumers who need plates for unessential purposes are not in such a happy position. The demand for plates is largely from the shipyards, but big quantities are being taken up by the boiler and tank makers and the constructional engineers. The latter industry, however, is not so well employed as was the case a few months ago and the demand for heavy joists and sections fails to revive. Bars appear to be required in ever-increasing quantities and big tonnages are passing to the general engineering works, most of which are employed upon war production in one form or another. The armament and munition makers are all extremely busy and there is a big demand for special steels. The producers of this material are exceptionally busy and their order books carry enough work to keep them fully engaged for a long time. The iron and steel industry in South Wales is being operated practically at capacity. The demand from the shipyards is keeping the heavy steel makers exceptionally busy. The tin-plate industry has experienced a better demand of late than for some weeks, and there is a sharp request for sheet and tin-plate bars.

Copper and Tin

The British copper position continues to be satisfactory and, notwithstanding the intensified German effort to blockade this country, supplies appear to be arriving regularly. Consumers engaged in the war industries are obtaining all the metal they require. In fact, in some cases in which copper was urgently needed it has been found possible to accelerate delivery by a week or two. The Control, however, is naturally keeping a watchful eye upon the position and is probably laying up a certain amount of metal as a reserve stock for use in an emergency. All the consuming industries are exceedingly busy and almost without exception are engaged upon war work. The cable industry is one of the largest users of copper and is working at capacity. In the United States the home consumption has been greatly increased by the needs of the rearmament programme. There have been some inquiries for copper for export, but so far as is known these have proved ineffectual. Prices are practically unchanged at 12c. d/d for home consumption. The export price is officially 11c., but it is difficult to obtain any quantity at this figure, and 11c. to 11⅛c., f.a.s., would probably be a more accurate quotation for export business. Consumers who are badly in need of small quantities of copper, it is reported, have paid 13c. for metal from second hands. . . . A firmer tone has ruled in the tin market. This movement followed a price advance in the East. Buying by American consumers, however, has been quiet and export licences have not been issued with the same freedom as a week or two ago. Business with America has been largely confined to a big order from a Government Department, but at the present prices ruling in this country and the United States it scarcely pays to ship copper to the latter country. On the other hand, it is suggested that there is no sound reason why prices should be at their present high level since in the United States the quotation is at 50c. and the world production appears to be ahead of consumption. The position in the United States is that the Government buys at 50c. and that ordinary consumers pay slightly more. The backwardation on the London market has increased and at one time stood at £5 in spite of Government sales of cash tin.

Lead and Spelter

The lead position in Great Britain is comfortable and supplies are more easily obtained probably than in the case of other non-ferrous metals. Obviously the Control has to exercise caution in distributing lead, but the war industries are obtaining their full requirements and there seems some surplus available for firms engaged upon other work. In the United States the official price is maintained at 5·85c., New York, by arrangement between the producers and the Government. Consumption is on a high level, largely as a result of the rearmament programme, and stocks are probably a little tight, although it is thought that most of the works hold fairly good reserves. The fixing of the maximum price was designed to prevent consumers rushing in to acquire stocks in view of Government orders they may have or hope to receive. There has been some talk of importing lead into the United States, but this was probably another effort to exert a quietening influence upon consumers. . . . The spelter position continues tight, probably for every country excepting Germany, who, having overrun so much of Europe, has a large smelting capacity in her hands. It is unlikely, however, that these plants can be fully employed, since to do so it would be necessary in some cases to import ores. In the United States the position is stringent, but the price remains steady at 7·25c., East St. Louis. No export business has been transacted in the United States since all the available metal is required for home consumption. India has been inquiring, but apparently no spelter is obtainable for that destination from America. Arrangements are understood to have been made to supply India with Australian and Canadian spelter, since India is, of course, participating in the war effort. It is possible that production will be considerably increased in the United States during April, as it is believed that additional smelting plant will be brought into operation in that country. On the other hand, it is probable that the speeding up of the American rearmament programme will take care of the additional supplies.

Notes and Memoranda

Rail and Road

MORE SCRAPPED RAILWAYS.—Permission has been obtained to dismantle and sell as scrap the rails of the Welsh Highland Railway, a 2ft. gauge line extending from Portmadoc to Dinas, near Caernarvon. The Van Railway, from Caersws to the Van mines, in Mid-Wales, is also being dismantled.

A MONSTER TRUCK.—The Greenville Steel Car Company, of Greenville, Pa., has completed a car to transport exceptionally large ingot moulds used in the production of ingots for the Carnegie-Illinois Steel Corporation, of Pittsburg. Its full load capacity is 250 tons; it weighs 140 tons, has a load limit of 234 tons, a total rail load of 380 tons, and an overall length of 90ft.

FOR CAR WINDOWS.—A safety glass has been marketed in America, which is claimed to have a strength greatly in excess of that of ordinary safety glass. The product is the usual type of glass sandwich, but the vinyl plastic filling in this case extends beyond the edges of the glass and serves as a flexible and rubber-like edge that can be bolted, screwed, or even nailed into window openings.

AERIAL CABLEWAYS.—If and when the Italians leave East Africa for good and all, they will leave several aerial cableways constructed by Italian engineers. The longest is the one between Massawa and Asmara, 44½ miles in length. It was opened in March, 1937, and was intended to relieve the congestion in the port and on the railway. The working capacity of that cable is 300 tons a day. Other public cableways are those at Dante and Amara. Some shorter industrial cableways are privately owned.

A TRAIN FOR PROPAGANDA.—The Baltimore and Ohio Railroad Company has inaugurated a special train to tour Indiana and Illinois, with the object of advocating more widespread use for the soya bean, which is largely grown in the Middle West. The train consists of six cars, and, in addition to the company's staff, accommodates lecturers from the Ohio, Purdue and Illinois Universities, who describe the raising, marketing, processing, and uses of soya beans. A travelling cookery school is a feature of the venture.

WAGON BUILDING.—The U.S.A. Defence Programme has entailed an enormous increase in orders for freight wagons. Thus, the Pennsylvania has on order in its own shops 2500 gondola cars, 2000 50-ton box wagons, 600 bulk container cars, and 200 caboose cars—5300 vehicles in all. The Union Pacific is building 2250 50-ton box cars of different types, and is inquiring outside its own shops for 300 flat cars and 50 mill type gondola cars. The Northern Pacific has placed orders with contracting wagon-building concerns for 2500 cars of various types. The foregoing is new business, supplementing the 1940 output of 65,545 new wagons, as compared with 24,528 in 1939.

Air and Water

PANAMA CANAL TRAFFIC.—During the month of February traffic through the Panama Canal was 363 ocean-going ships and eighty small ships, paying tolls amounting to 1,363,203 dollars.

THE LIFEBOAT SERVICE.—Lifeboats of the Royal National Lifeboat Institution were launched ninety times during the month of March and rescued 132 lives; 601 rescues have been made since the beginning of this year, an average of six a day.

CLARIFICATION OF WATER SUPPLY.—The situation of a high-grade bauxite deposit near Umtali, in Southern Rhodesia, has been followed by the beginnings of plans to manufacture in South Africa aluminium sulphate, an approved coagulant used in the clarification of water by municipalities and water supply undertakings. In the past, the South African market has had to rely on British and Continental sources for its supplies of this important product.

VOLGA-BALTIC CANAL.—It is reported in the *Journal of Commerce* that the last link in the Volga-Baltic waterway, from Beloye Ozero to Leningrad, is now undergoing reconstruction. New locks, dams and other structures are being built. Wharves, shipbuilding yards and landing stages are being built along the whole length of the waterway from Moscow to the Baltic Sea. It is expected that the reconstructed Moscow-Rybinsk section will be open for freight and passenger traffic during the navigation season of 1941.

THE ST. LAWRENCE PROJECT.—The St. Lawrence water scheme is being seriously opposed by railway interests in America. Representative Van Zandt, Republican of Pennsylvania, asserted in a recent statement that there is not room for both the railways and the waterway. Mr. Van Zandt has since backed up the views of railway interests by endorsing a plea that the "nation needs planes, ships, guns, and ammunition, and other materials for defence right now more than the St. Lawrence waterway project as contemplated, since even if it is promoted it cannot possibly be placed in successful operation before eight or ten years have elapsed."

TRAINING OF CANAL BOATMEN.—The Minister of Transport, in a letter to all canal carriers, has stated that the training of canal boatmen for the purpose of bringing back into service boats lying idle, is to be encouraged by the offer of grants payable to the carrying companies. The grants will be made towards the additional costs arising from the employment of inexpert labour during the period of training. Grants at the rate of £10 for each man trained will be payable on the completion of the training period, provided the Minister is satisfied that as a result of training more men the carrying company has made an addition to the number of boats in service. A further condition is that employment shall continue for a year after training.

Miscellanea

A NEW CHAIR.—Funds have recently been provided by the directors of A. B. Bofors, the Swedish armament steel works, for a professorial chair in technical physics at the Stockholm Technical University and for establishing a research laboratory in connection with the post. Professor Waloddi Weibull will be the first occupant.

TO LIGHT AND COOK.—An American concern making searchlights, has devised a portable electric kitchen for a coast artillery battery at Fort Bliss, near El Paso, Tex., which utilises the portable searchlight power unit to supply power for an electric hot plate and electric oven. This is said to be the only portable electric field kitchen in the United States Army.

CALCIUM IN METALLURGY.—The research chemist continues to find new uses for calcium in the metallurgical industry. Recent results include its utilisation as a deoxidiser and alloying agent for non-ferrous metals, such as copper and lead, in the preparation of high-temperature, high-resistance nickel-chromium and nickel-chromium-iron alloys, and in the form of its hydrides as a reducing agent for the production of rare metals, such as titanium, vanadium, uranium and zirconium.

FOR THE PLASTER INDUSTRY.—Particulars have been published of a chemical salt similar in composition to plaster of paris (magnesium sulphate), which has been produced by heating gypsum in a solution of magnesium sulphate. The product has been found to be about twice as strong as that obtained from plaster of paris and, indeed, approaches the strength of Portland cement. It is not expensive to produce and among suggested uses are those of tiles, wall boards and pre-cast building products.

MONEL BALL BEARINGS.—In certain circumstances ball bearings need to be resistant to corrosion to a high degree or non-magnetic. A Monel nickel alloy has been adapted for bearings used for applications where corrosive conditions would ruin regular steel bearings. They can also be used around magnetic compasses without causing the slightest deflection, for they are completely non-magnetic. Each application calls for care, because the load-carrying limits of the alloy are lower than those of standard steel bearings.

AMERICA CONTROLS MINES IN ARGENTINA.—All the tungsten mines in the department of Iglesias, 700 miles north-west of Buenos Aires, in the Andean, San Juan, have been leased to United States interests trading as Granfor, Keen and Co. The lease, which was obtained from the Government, will run for ten years and the American company will pay 7 million dollars for it. The Department of Iglesias ranks fifth as a producer of the metal. In 1938 production reached 1098 tons, while the figures for 1939 rose to 1200 tons.

TUNGSTEN CONCENTRATES.—Tungsten ores are found in eighteen countries, Burma and China providing the most. The peak supply from Burma was reached in 1938 with 11,410 tons, and from China in 1937 with 17,895 tons. China dropped to 13,400 tons in 1938 and to 10,000 tons in 1939, the latest available figures. Burma in that year nearly maintained its output at 11,000 tons. The main deposits in Burma lie in the Kyankse district in the north through Yamethen, and through the Southern Shan States for a distance of about 750 miles.

TAPERED TUBES.—The steel tubes department of the Republic Steel Corp. of Cleveland, Ohio, has adapted what is known as the Dewey tube forming process so as to make tubing with tapers up to 20ft. long or with any combination of tapers and curves in the same length, with reductions in diameter up to 50 per cent. Thus tubular automotive propeller shafts can be made a constant-strength beam by tapering from the ends to the centre, instead of tapering for only a short distance from each end. Aircraft landing gear struts can follow similar design, instead of using a stamped and welded assembly.

DAMAGE FROM VIBRATION.—In these times of alarms and excursions the research worker turns to matters not commonly investigated and "earthquakes" produced by men, and their possible effects in structures of various kinds was the subject of a paper by Mr. S. L. Windes, seismologic observer of the Bureau of Mines, U.S., at the College of Engineering, University of Maryland. Following tests conducted over a period of five years to determine the possible damage that may be caused to various types of buildings from earth vibrations set up by blasting at nearby quarries, the Bureau has now contrived a mechanical "house shaker," with which to agitate different kinds of structures to a point where actual but controlled damage is inflicted. The purpose is to ascertain the manner in which structures of the residential type vibrate; to correlate mechanically induced house vibrations with ground vibrations from quarry blasting; and to establish an index of damage from ground vibrations.

Personal and Business

MR. F. A. DERBY, publicity manager of Cunard White Star, Ltd., has retired.

SIR JOHN PRESTIGE has been installed as Second Master of the Worshipful Company of Shipwrights.

THE Minister of Works and Buildings announces the appointment of Mr. Hugh Beaver, M. Inst. C.E., as Director-General, Works and Buildings.

MR. E. F. BONE, assistant to the Southern Railway Docks and Marine Manager, Southampton, is retiring at the end of the month. His successor is to be Mr. E. Burrows.

THE EDISON MEDAL.—This, the highest award of the American Institute of Electrical Engineers, was presented to Dr. G. Ashley Campbell, retired research engineer of the Bell Telephone Laboratories, at a special session of the winter convention, held in Philadelphia, Pa. The Edison Medal is presented annually to a resident in the United States of America or its dependencies, or of the Dominion of Canada, for "meritorious achievement in electrical science or electrical engineering or the electrical arts."

MR. F. GURNEY, lately manager of the Metropolitan-Vickers company's sub-office at Leeds, has been appointed sales manager of the transformer department in place of the late Mr. G. E. Gittins. Mr. R. P. Horlock has been appointed to succeed Mr. Gurney as manager of the Leeds sub-office.

THE Minister of Shipping regrets to announce that Sir John Niven, who has served as Director of Commercial Services since the formation of the Ministry of Shipping, has resigned for health reasons. Mr. George P. Christopher, Deputy Director of Commercial Services since the formation of the Ministry, has succeeded Sir John Niven as Director of Commercial Services.

BRITISH INSULATED CABLES, Ltd., announces that, after forty-six years' service with the company, Mr. E. A. Bayles retired from the position of works manager at Helsby on March 31st. Mr. Bayles is to retain his association with the company in a consultative capacity in technical matters. Mr. G. H. Walton has been appointed to succeed him as works manager.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Institute of Fuel

Wednesday, April 30th.—Royal Victoria Station, Sheffield. "Research and the Coking Industry," E. W. Smith. 2.30 p.m.

Institution of Chemical Engineers

Tuesday, May 13th.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "Economical Raising of Steam in Small and Medium-size Boiler Plants," G. W. Himus. 2.30 p.m.

Institution of Civil Engineers

Tuesday, April 29th.—Great George Street, Westminster, S.W.1. "The Mechanical Behaviour of Solids," E. N. da C. Andrade. 1.30 p.m.

Institution of Electrical Engineers

Thursday, May 8th.—Savoy Place, Victoria Embankment, W.C.2. "Electrical Works by Helios, or the Sun and the Ionosphere," S. Chapman. 2.30 p.m. Annual general meeting, 3.45 p.m.

Institution of Engineers-in-Charge

Friday, May 9th.—Holborn Restaurant, High Holborn, W.C.1. Annual dinner. 5 for 5.30 p.m.

Institution of Locomotive Engineers

Wednesday, April 30th.—Inst. of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "Diesel Shunting Locomotives," C. E. Fairburn. 5 p.m.

Institution of Mechanical Engineers

To-day, April 25th.—Storey's Gate, Westminster, S.W.1. "Mechanical Mishaps," G. E. Windeler. 2 p.m.

Institution of Structural Engineers

To-day, April 25th.—Dorchester Hotel, London, W.1. Luncheon, 1 for 1.15 p.m.

Iron and Steel Institute

Thursday, May 1st.—Grosvenor House, Park Lane, W.1. Luncheon. 12.45 for 1 p.m. Annual meeting. 2.30 p.m. For programme see page 248.

Junior Institution of Engineers

Saturday, April 26th.—Holborn Restaurant, High Holborn, W.C.1. Luncheon. 1 for 1.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, April 25th.—Mining Institute, Newcastle-upon-Tyne. "Plastic Theory: Its Application to Design," J. F. Baker and J. W. Roderick. 6 p.m.

North of England Institute of Mining and Mechanical Engineers

Saturday, April 26th.—Neville Hall, Newcastle-upon-Tyne. "The Prevention of Gas Ignition in the Overcut," R. D. Beilby. 2 p.m.

Royal Institution of Great Britain

Thursday, May 1st.—21, Albemarle Street, W.1. Annual meeting. 5 p.m.

Society of Chemical Industry

To-day, April 25th.—NEWCASTLE SECTION: King's College, Newcastle-upon-Tyne. "Reflections on the Philosophy of Science," F. G. Donnan. 6 p.m.

CATALOGUES

SAUNDERS VALVE COMPANY, Ltd., Cwmbran, Newport, Mon.—Handbook 740 on valves.

FERODO, Ltd., Chapel-en-le-Frith, Derbyshire.—Illustrated brochure on the testing of friction materials.

JOHN M. HENDERSON AND CO., Ltd., King's Works, Aberdeen.—Catalogue No. 85–1E on Henderson winches.

HADFIELDS, Ltd., East Hecla Works, Sheffield.—Catalogue No. 445 of colliery, quarry and mining requisites.

HOLOPHANE, Ltd., Elverton Street, Vincent Square, S.W.1.—Catalogue No. 4000 of scientific lighting equipment.

BRITISH CUTTING GASES, Ltd., Spartan Works, Carlisle Street, Sheffield, 4.—Booklet dealing with "Pyrogas."

SUMO PUMPS, Ltd., Lighthouse Works, Smethwick, Birmingham.—List C E 1 on Sumo deep well pumping equipment.

BRITISH INSULATED CABLES, Ltd., Prescot, Lancs.—Folder illustrating the adaptations of detachable pocket type disconnecting network boxes.

NEGRETTI AND ZAMBRA, 38, Holborn Viaduct, E.C.1.—Leaflets on the "Multipoint" temperature indicator, recording pyrometers, and pyrometer controllers.

ENGLISH ELECTRIC COMPANY, Ltd., Queen's House, Kingsway, W.C.2.—Publications No. 947B on Class O K D Outdoor Frame-mounted Oil Circuit Breakers, and No. S 30A on Back-pressure Turbines.